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ERRATA.

Vol. xlii, p. 271, l. 1 and 7 from top, for H. St. Claire Deville, read F. Pisani.
In No. cxxvii, page 87, line 25 *from* top, for 12h 39m 0s, read 12h 59m 0s.

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LAWRENCE SCIENTIFIC SCHOOL CHEMICAL DEPARTMENT

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[SECOND SERIES.]

ART. I.—*On the construction of a Normal Map of the Solar Spectrum.* An abstract of a memoir read before the National Academy of Sciences, Aug. 7th, 1866; by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

THE extraordinary impulse which has been given to the study of the spectrum by the investigations of Bunsen and Kirchhoff has led to an accumulation of details which have not yet been systematically or even conveniently arranged. To a certain extent at least this has arisen from the want of a standard map of the solar spectrum upon which new lines may be entered with precision as regards their relative places. The well known chart of Kirchhoff, though executed with great care and labor, is not, properly speaking, normal, since it only represents a spectrum formed by four flint glass prisms, the angles of which, it is true, are given, but of which the indices of refraction are not stated. Moreover the prisms were not placed accurately in the positions of least deviation for each of the spectral lines. The scale of millimeters adopted by Kirchhoff is therefore a purely arbitrary one.

A standard or normal map of the spectrum must be wholly independent of peculiarities in the form of apparatus, in the number of prisms, their refractive and dispersive powers and their positions. Such a map can only be based upon the wave lengths of the spectral lines, since these do not, like the indices of refraction, vary with the material of which the prisms are composed.

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The diffraction spectrum as obtained by a glass plate ruled with from one to ten thousand lines to the inch gives a nearer approach to a perfectly normal spectrum than any which has hitherto been proposed, and has been employed by Fraunhofer,* Mossotti† and Draper.‡ But even in this case there is a position of least deviation for each line depending upon the angle which the incident beam of light makes with a normal to the plane of the ruled surface, and in addition, it is necessary either to fix upon a standard number of lines to be ruled upon each millimeter of glass surface, or to reduce the positions of the spectral lines to those which would have been obtained with a standard ruled surface.

We avoid all these difficulties by constructing a normal spectrum in such a manner that each spectral line shall be entered according to its wave length, a method first suggested, I believe, by Billet.§

The materials which the present condition of science furnishes for the construction of a chart of the spectrum upon the principle laid down are not very copious. They consist essentially of the older measurements of Fraunhofer‖ of the wave lengths of the lines B, C, D, E, b, F, G and H; of recent and very accurate measurements by Angström;¶ of a still more extended series by Ditscheiner;** of the measurements of Plücker†† for certain lines in the spectra of gaseous media, and of those of Esselbach‡‡ for the ultra-violet rays. In addition we have a small number of isolated measurements by Müller,§§ Mascart,‖‖ Stefan,¶¶ and Ketteler.***

For the construction of the chart which I present herewith to the Academy I have selected the wave lengths determined by Angström as standards. This has been done because both the ruled glass and the measuring apparatus employed by him appear to have been much more perfect than those of other observers—Fraunhofer not excepted. On the other hand, however, all of Angström's measures are not available for the reason that the identification of the lines as produced by particular elements does not appear to be in all cases absolutely certain. As Angström's measurements are in ten-millionths of a Paris inch they have been reduced to millionths of a millimeter by multiplying them by the constant 27·07.

Ditscheiner's measurements agree closely with those of Ang-

* Denkschr. Münch. Acad., Bd. viii, 1821–22.
† Annali delle Univer. Toscane, t. i, 1845; also Pogg. Ann., lxii, p. 509.
‡ L. & E. Phil. Mag., xxvi, 1845.
§ Traite d'Optique, vol. i, p. 47.
‖ Loc. cit.
¶ Pogg. Ann., cxxiii, p. 489.
** Sitzungsberichte der k. k. Akad. der Wiss., Bd l, 1864.
†† Pogg. Ann., cvii, p. 497.
‡‡ Pogg. Ann., xcviii, p. 513.
§§ Pogg. Ann., cxviii, p. 641 and cxxix, p. 637.
‖‖ Pogg. Ann., cxviii, 367.
¶¶ Pogg. Ann., cxxii, p. 634.
*** Pogg. Ann., cxxiv, p. 390.

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ström after undergoing a correction which depends upon the value of the wave length of the more refrangible line of D. This value is taken by Ditscheiner as 588·8, the wave length as determined by Fraunhofer. But as, for the reasons above mentioned I consider the results of Angström more reliable, I have taken his value, 589·43, in place of that of Fraunhofer, and have reduced all the measurements of Ditscheiner in accordance with this assumption. The following table will suffice to show the agreement between the two series of measurements.

TABLE I.

Angström.	Ditscheiner.	Diff.	Angström.	Ditscheiner.	Diff.
687·49	687·81	+0·32	527·32	527·42	+0·10
656·76	656·66	−0·11	523·69	523·74	+0·05
619·17	619·72	+0·55	519·63	519·67	+0·04
617·08	617·50	+0·42	518·79	518·73	+0·06
616·33	616·73	+0·40	517·66	517·70	+0·04
614·31	614·24	−0·07	517·15	517·15	0·00
612·34	612·76	+0·42	492·23	492·22	−0·01
610·45	610·82	+0·36	491·41	491·41	0·00
590·04	590·07	+0·03	489·50	489·54	+0·04
589·43	589·43		487·55	487·55	0·00
561·99	561·98	+0·01	486·52	486·49	−0·03
560·70	560·77	+0·07	440·81	440·87	+0·06
559·10	559·13	+0·03	438·63	438·75	+0·12
557·66	557·77	+0·11	434·28	434·34	+0·06
545·97	546·05	+0·08	432·78	432·82	+0·04
545·07	545·08	+0·01	431·03	431·35	+0·32
534·41	534·41	0·00	397·16	397·10	−0·06
533·16	533·29	+0·13	393·59	393·74	+0·15
528·73	528·79	+0·06			

A number of Ditscheiner's measurements refer to lines which cannot certainly be identified with the lines produced by particular elements. These lie between G and H and have been omitted as useless for our present purpose. But in the greater number of cases the wave lengths in his table of results are referred directly to the lines given in Kirchhoff's chart, which not merely enables us to identify them, but permits us to obtain the wave lengths of the intermediate lines by interpolation. The following table gives the corrected values of all the wave lengths measured by Ditscheiner with the exception of those between G and H, and of those of the nine principal lines of Fraunhofer which are given in Table I.* For these I have taken the values given by Angström. I have not ventured to make a further use of Angström's determinations for the reason that it is only through a comparison with the measurements of Ditscheiner that they can be identified with the lines upon Kirchhoff's scale. In every part of the spectrum excepting that between C and D the agreement between the two sets of measurements appears to fall within the limits of the errors of observation.

* Marked in Table II with asterisks.

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TABLE II.

Kirchhoff's Line.	Wave Length.	Kirchhoff's Line.	Wave Length.	Kirchhoff's Line.	Wave Length.	Kirchhoff's Line.	Wave Length.
A 404·5	*761·20	1242·6	557·77	1737·7	511·42	2221·7	474·34
B 592·7	*687·49	1280·0	553 27	1750·4	510·30	2233·7	473·36
C 694·1	*656·77	1303·5	551 13	1777·5	508·41	2250·0	472·26
711·4	652·09	1306·7	550·70	1799·0	506·91	2264·3	470·21
719·6	650·05	1324·8	548·13	1834·3	504·55	2309·0	467·07
783·8	634·05	1337·0	546·78	1854·9	503·25	2416·0	460 63
831·0	623 61	1343·5	546·05	1867·1	502·26	2436·5	458·66
849·7	619·72	1351·1	545·08	1873·4	501·67	2457 5	456·81
860·2	617 50	1367·0	543·42	1885·8	501·07	2467 6	455·71
863·9	616·73	1389·4	540 91	1908·5	499·72	2489·4	453·73
874·3	614·74	1410·5	538·79	1920·2	498·78	2537·1	450·56
877·0	614·24	1421·5	537·52	1960·8	496·15	2547·2	450·13
884·9	612·76	1449·4	534·41	1975·7	495·04	2566·3	448·46
894·9	610·82	1463·3	533·29	1983·3	494·34	2606·6	446·00
959·8	598·14	1492·4	530·22	1989·5	493·76	2627·0	444·65
Dβ 1002 8	*590·04	1506·3	528·79	2001·6	492·22	2638·5	443·85
Dγ 1005·0	589·74	1515·5	528·02	2018·5	491·41	2670·0	442·29
Da 1006·8	*589·43	E 1523·7	*527·38	2041·3	489·54	2686 6	440·87
1029·3	586·26	1541·9	525·98	2058·0	488·18	2721·6	438·75
1096·1	576·72	1569 6	523·74	2067·1	487 55	2734·1	437·80
1102·9	575·78	1577·6	523·09	F 2080·0	*486·52	2775·7	435·67
1135·1	571·51	1589·1	521·97	2103·3	484·63	2796·7	434·34
1155·7	568·70	1601·7	521·32	2119·8	482·81	2822·3	432·82
1174 2	566 33	1622·3	519 67	2148·9	480·56	G 2854·7	*431·03
1200.6	562·97	1634·1	518 73	2157·4	479 55	2869·7	430·37
1207·3	561·98	b 1648·8	517·70	2160·6	479·23	H	*397·16
1217·8	560·77	1655 6	517·15	2187·1	476·93	H′	*393·59
1237·8	559·13	1693·8	514·65	2201·9	475·90		

Table II, embracing determinations of 111 wave lengths, has served as the basis for the construction of the interpolation curves which are herewith submitted to the Academy.

By means of these curves the values of the wave lengths for every tenth line of Kirchhoff's scale from line 694 or C, to line 2854·7 or G, have been determined. These values are given in the following table. Similar relations cannot at present be found for the lines between A and B, or between B and C, on account of the absence of the requisite measurements.

TABLE III.

Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference
700	655 05	2·70	800	630·30	2·20	900	609·72	2·27	1000	590·45	1·65
10	652·35	2·65	10	628·10	2·10	10	607·45	1·95	10	588·80	1·70
20	649·70	2·60	20	626·00	2·10	20	605·50	1·95	20	587·10	1·65
30	647·10	2·50	30	623·90	2·05	30	603·55	1·90	30	586·05	1·50
40	644·60	2·50	40	621·85	2·18	40	601·65	1·85	40	584·55	1·50
50	642·10	2·50	50	619·67	2·20	50	599·80	1·80	50	583·05	1·40
60	639·60	2·40	60	617·47	1·85	60	598·00	2·30	60	581·65	1·40
70	637·20	2·30	70	615·62	1·92	70	595 70	1·85	70	580·25	1·40
80	634·90	2·30	80	613·70	2·01	80	593·85	1·70	80	578·85	1·35
90	632·60	2·30	90	611·69	1·97	90	592·15	1·70	90	577·50	1·30

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TABLE III—(continued.)

Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.	Kirchhoff's Scale.	Wave Length.	Difference.
1100	576·20	1·45	60	524·25	0·85	10	492·05	0·80	70	455·65	0·85
10	574·75	1·40	70	523·45	0·80	20	491·25	0·75	80	454·80	0·85
20	573·35	1·35	80	522·70	0·75	30	490·50	0·90	90	454·05	0·75
30	572·00	1·35	90	521·95	0·75	40	489·60	0·80	2500	453·30	0·75
40	570·65	1·35	1600	521·20	0·70	50	488·80	0·80	10	452·55	0·75
50	569·30	1·25	10	520·50	0·75	60	488·05	0·75	20	451·80	0·70
60	568·05	1·25	20	519·75	0·70	70	487·30	0·84	30	451·10	0·70
70	566·80	1·30	30	519·05	0·70	80	486·46	0·86	40	450·40	0·65
80	565·50	1·30	40	518·35	0·70	90	485·60	0·75	50	449·75	0·70
90	564·20	1·30	50	517·65	0·70	2100	484·85	0·82	60	449·05	0·65
1200	562·90	1·25	60	516·90	0·75	10	484·03	1·26	70	448·40	0·70
10	561·65	1·20	70	516·15	0·75	20	482·77	1·17	80	447·70	0·65
20	560·45	1·20	80	515·45	0·70	30	481·60	0·60	90	447·05	0·65
30	559·25	1·20	90	514·75	0·70	40	481·00	0·74	2600	446·40	0·65
40	558·05	1·25	1700	514·00	0·75	50	480·26	0·97	10	445·75	0·65
50	556·80	1·20	10	513·30	0·70	60	479·29	1·29	20	445·10	0·65
60	555·60	1·10	20	512·60	0·70	70	478·00	1·13	30	444·45	0·70
70	554·50	1·20	30	511·85	0·75	80	476·87	0·61	40	443·75	0·70
80	553·30	1·05	40	511·15	0·70	90	476·26	0·34	50	443·05	0·60
90	552·25	1·10	50	510·45	0·70	2200	475·92	0·62	60	442·45	0·70
1300	551·15	0·79	60	509·65	0·80	10	475·32	0·82	70	441·75	0·60
10	550·36	1·54	70	508·95	0·70	20	474·50	0·80	80	441·15	0·60
20	548·82	1·35	80	508·25	0·70	30	473·70	0·90	90	440·55	0·60
30	547·47	1·06	90	507·55	0·75	40	472·80	0·80	2700	439·95	0·60
40	546·41	1·31	1800	506·80	0·65	50	472·00	0·85	10	439·35	0·55
50	545·10	1·10	10	506·15	0·65	60	471·15	0·85	20	438·80	0·55
60	544·00	0·83	20	505·50	0·70	70	470·30	0·80	30	438·25	0·55
70	543·17	0·93	30	504·80	0·70	80	469·50	0·80	40	437·70	0·60
80	542·24	1·44	40	504·10	0·65	90	468·70	0·75	50	437·10	0·60
90	540·80	0·70	50	503·45	0·70	2300	467·95	0·75	60	436·50	0·60
1400	540·10	1·15	60	502·75	0·70	10	467·20	0·75	70	435·90	0·60
10	538·83	1·06	70	502·05	0·65	20	466·45	0·65	80	435·30	0·55
20	537·77	1·34	80	501·40	0·50	30	465·80	0·65	90	434·75	0·55
30	536·43	1·20	90	500·80	0·60	40	465·15	0·65	2800	434·20	0·60
40	535·23	0·80	1900	500·20	0·65	50	464·50	0·65	10	433·60	0·60
50	534·43	0·83	10	499·55	0·65	60	463·85	0·60	20	433·00	0·55
60	533·60	0·94	20	498·90	0·65	70	463·25	0·60	30	432·45	0·55
70	532·66	1·16	30	498·25	0·65	80	462·65	0·60	40	431·90	0·60
80	531·50	1·00	40	497·55	0·75	90	462·05	0·55	50	431·30	0·60
90	530·50	0·95	50	496·80	0·70	2400	461·50	0·55	60	430·70	0·60
1500	529·55	0·95	60	496·10	0·70	10	460·95	0·95	70	430·10	
10	528·60	0·95	70	495·40	0·85	20	460·00	0·90			
20	527·65	0·90	80	494·55	0·80	30	459·10	0·85			
30	526·75	0·90	90	493·75	0·80	40	458·25	0·90			
40	525·95	0·85	2000	492·95	0·90	50	457·35	0·85			
50	525·10					60	456·50				

To find the wave length of any line in Kirchhoff's table, or upon his chart, from Table III, it is only necessary to employ the simple formula $\lambda' = \lambda - \frac{1}{10}(\varkappa' - \varkappa)\,\Delta\lambda$ in which λ' represents the wave length sought and $\varkappa'$ the corresponding line upon Kirchhoff's scale; λ the wave length of the next lower line $\varkappa$ in Table III, and $\Delta\lambda$ the corresponding difference also given in the table. It is not necessary in any case to employ second differences. The following table will serve to

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show the degree of accuracy attainable by means of the formula above given and the data in Table III.

TABLE IV.

Kirchhoff.	Calcul.	Found.	Diff.	Kirchhoff.	Calcul.	Found.	Diff.	Kirchhoff.	Calcul.	Found.	Diff.
711·4	651·96	652 09	−0·03	1421·5	537·57	537·52	+0·05	2067·1	487·52	487·55	−0·03
719·6	649·81	650·05	−0·24	1449·4	534·48	534·41	+0·07	2080·0	486·46	486·52	−0·06
783·8	634·03	634·05	+0·02	1463·4	533·29	533·29	0·00	2103·3	484·58	484·63	−0·05
831·0	623·69	623·61	+0·08	1492·4	530·28	530·22	+0·06	2119·8	482·80	482·81	−0·01
849·7	619·87	619 72	+0·15	1506·3	528·95	528·79	+0·16	2148·9	480 60	480·56	+0·04
860·2	617·44	617·50	−0·06	1515·5	528·08	528·02	+0·06	2157·4	479·55	479·55	0·00
863 9	616·75	616·73	+0·02	1523·7	527·30	527·38	−0·08	2160·6	479 23	479·23	0·00
874·3	614·80	614·74	+0·06	1541·9	525·80	525·98	−0·18	2187·1	476·44	476·93	−0·49
877·0	614·28	614 24	+0·04	1569·6	523·48	523·74	−0·26	2201·9	475·78	475·90	−0·12
884·9	612·72	612·76	−0·04	1577·6	522·88	523·09	−0·21	2221·7	474 37	474·34	+0·03
894·9	610·73	610·82	−0 09	1589·1	522·02	521·97	+0·05	2233·7	473·37	473·36	+0·01
859·8	598·40	598·14	+0·26	1601·7	521·07	521·32	−0·25	2250·0	472·00	472·26	+0·26
1002·8	589 99	590·04	−0·05	1622·3	519·58	519·67	−0·09	2264·3	470·79	470·71	+0·08
1004·8	589·66	589·74	−0·08	1634·1	518·76	518·73	+0·03	2309·0	467·27	467·07	+0·20
1006·8	589·33	589 43	−0·10	1648·8	517·73	517·70	+0·03	2416 0	460·62	460·63	−0·01
1029·3	586·17	586·26	−0·09	1655·6	517·26	517·15	+0·11	2436·5	459 51	458·66	+0·85
1096 1	576·78	572·72	+0·06	1693·7	514·49	514·65	−0·16	2457·5	456·71	456·81	−0·10
1102·9	575·82	575·78	+0·04	1737·7	511·27	511·42	−0·15	2467 6	455·85	455·71	+0·14
1135·1	571·31	571·51	−0·20	1750·4	510·42	510·30	+0·12	2489·4	453·35	453·73	−0·38
1155·7	568·53	568·70	−0·17	1777·5	508·42	508·41	+0·01	2537·1	450·60	450·56	+0·04
1174·2	566·27	566·33	−0·06	1799·0	506·87	506·91	−0·04	2547·2	449·93	450 13	−0·20
1200·6	562·82	562·97	−0·15	1834·3	504·50	504·55	−0·05	2566·3	448·64	448·46	+0·18
1207·0	561·99	561·98	+0·01	1854·9	503·11	503·25	−0·14	2606·6	445 97	446·00	−0·03
1217·8	560·67	560·77	−0 10	1867·1	502·25	502·26	−0·01	2627·0	444·64	444·66	−0·01
1237·8	558·31	559·13	−0·32	1873·4	501·85	501·67	+0·18	2638·5	443·85	443·85	0·00
1242·6	557·74	557·77	−0·03	1885·8	501·05	501·07	−0·02	2670·0	441·75	442·29	−0·54
1280·0	553·30	553·27	+0 03	1908·5	499·65	499·72	−0·07	2686 6	440·75	440·87	−0·12
1303·5	550·88	551·13	−0·25	1920·2	498·89	498·78	+0·11	2721 6	438·71	438·75	−0·04
1306·7	550·61	550·70	−0·09	1960·8	496·04	496·15	−0·11	2734·1	438·02	437·80	+0·22
1324·8	548·18	548·13	+0·05	1975·7	495·00	495·04	−0·04	2775·7	435·56	435·67	−0·11
1337·0	546·73	546·78	−0·05	1983·3	494·48	494·34	+0·14	2796·7	434·38	434·34	+0·04
1343·5	545·96	546·05	−0·09	1989·5	493·71	493·75	−0·04	2822·3	432 86	432·82	+0·04
1351·1	544·98	545·08	−0·10	2001·6	492·81	492·22	+0·59	2854 7	431·60	431·03	+0·57
1367·0	543·42	543·42	0·00	2018·5	491·37	491·41	−0·04	2869·7	430·08	430·37	−0·21
1389·4	540·89	540·91	−0·02	2041·3	489·50	489·54	−0·04				
1410·5	538·78	538·79	−0·01	2058·0	488·16	488·18	−0·02				

From the above table it will be seen that wave lengths may usually be determined correctly in the first decimal place when the corresponding line upon Kirchhoff's scale is known to the tenth of one millimeter. From Table I it will be seen that wave lengths as determined by two observers differ almost always by several units in the second decimal, and not rarely even in the first, so that Table III will give results within the probable errors of observation. It must however be remarked that the data for the calculation of Table III have not been equally numerous for equal intervals of Kirchhoff's scale, and the table is not therefore *equally* reliable in all its parts. New measurements of wave lengths are needed to give greater precision, especially between the numbers 890—1000 and 1030—1090.

Kirchhoff's measurements have not hitherto been extended beyond the line G. For this portion of the spectrum we pos-

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sess the beautiful photographic charts of Mr. Rutherfurd extending from b to H′. These charts are not however at present available for the determination of wave lengths, because the lines upon them beyond G have not yet been identified with lines whose wave lengths have been measured.

The very numerous measurements of Mr. Huggins* give the relative positions of a great number of spectral lines characteristic of particular elements. To give these measurements a real value the corresponding wave lengths must be determined as in the case of Kirchhoff's lines. I am not at present able to state to what extent this has been done, or whether it will be possible without a great number of new measurements of wave lengths to reduce the scale-numbers given by Mr. Huggins to the wave standard. If this can be done, we shall be able to fill up the portion of the spectrum beyond the line G not examined by Kirchhoff, and for which Ditscheiner's measurements are not available.†

In any event the tables and formula above given will enable an observer to determine the wave length of any new spectral line by simple comparison with Kirchhoff's chart, provided only that the line lies between B and G. In practice I suggest that this comparison may be readily made directly. Let for example three or four flint glass prisms be used with the spectroscope so as to give an amount of dispersion approximately equal to that of Kirchhoff's apparatus. If now a scale telescope be employed with an object glass of about 18 inches focal length, it will be easy to place Kirchhoff's chart in such a position that the reflected image of any small portion of it shall be in the field of view of the observing telescope at the same time with the direct image of the part of the solar spectrum containing the line the wave length of which is to be determined, which line may then also be brought into the field of view by means of a small prism covering a part of the slit of the collimator in the usual manner. If the scale telescope be provided with a rectangular prism placed at a convenient distance from the object glass and so that the hypothenuse of the prism shall make an angle of 45° with the vertical, the chart may be laid flat upon the table and moved into any convenient position. Finally, the magnitude of the reflected image of the scale may be reduced at pleasure by interposing a concave lens and suitably varying the distance of the scale. When the position of the given line with reference to any two adjacent lines, or to any scale number upon Kirchhoff's

* Philosophical Transactions for 1864; also Pogg. Ann., cxxiv, p. 275.

† Since the above was written I have succeeded, by comparing the lines upon Mr. Huggins' scale with those upon Kirchhoff's scale, in constructing interpolation tables for the former similar to Table III. These I shall hereafter publish in extenso together with the wave lengths of all the elements given by both observers. —W. G. Nov. 1st, 1866.

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chart, has been determined, the wave length may be found from Table III.

The determination of wave lengths by the method of comparison which I have explained above, is analogous to the determination of the place of a star by comparison with that of another star whose place is known. It is easy to see that when the wave lengths of a sufficient number of lines have been determined with accuracy for the purposes of comparison, the wave length of a given line may be found with very nearly as much precision as by direct measurement with a ruled glass. For in a large spectroscope with five or six prisms of high dispersive power, the angular separation of two lines differing in wave length by only a single millionth of a millimeter, is so great that the interval may be readily divided into hundredths. Of course the magnitude of this interval for the same system of prisms will differ in different parts of the spectrum, being greatest for the most refrangible rays. But the interval will always be sufficient to give us the advantage of determining a small difference in magnitude by the measure of a considerable distance in space. To the best of my knowledge this method of determining wave lengths is new.

The spectroscope enables us however to determine wave lengths by another method which, though not new in principle, has not received the attention which it deserves, and has been applied in practice only in certain cases. I refer to the employment of the interference bands of Talbot, an application first made by Esselbach* in the measurement of the wave lengths of the ultra-violet rays. The method in question exhibits an extraordinary degree of precision when a spectroscope with several prisms of high dispersive power is employed, since in this case interference plates of considerable thickness may be used so as to produce very numerous dark bands. By measuring the number of bands between the given spectral line and two other spectral lines whose wave lengths are known, the wave length of the line in question may at once be found.† This method possesses the further advantage, that by employing several interference plates of different thicknesses or different kinds of glass, a number of independent measurements may be made, the mean of which may be taken. A number of observations may also be made with a single plate and different pairs of comparison lines.

The chart which is herewith presented to the Academy must be regarded simply as a first approximation to a normal chart of the spectrum. It contains 187 lines, the wave lengths of which have been accurately determined. The chart is drawn to a scale of millimeters, and in entering the lines of the spectrum upon

* Pogg. Ann., xcviii, 513.

† See Müller's Lehrbuch der Physik und Meteorologie, Bd. i, p. 850.

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it each millimeter of the chart corresponds to the one-millionth of a millimeter of wave length. The probable error of measurement in determining the wave length does not usually exceed one or two ten-millionths of a millimeter, and the spectral lines have been ruled by a dividing engine upon the copper plate of the engraver so as to be correct in position to about one-tenth of a millimeter upon the chart. The substance generating each line is indicated by a dotted line and symbol as in Kirchhoff's chart, while the seven principal lines of Fraunhofer are denoted by the usual letters. In order to permit a comparison of the lines characteristic of different elements closely related to each other in their chemical properties, or belonging to the same natural groups, several impressions of the scale have also been printed upon a single sheet parallel to each other. Upon these the lines may be entered by hand. Copies of the scale have also been printed at the bottoms of large sheets so as to permit of the construction of dispersion curves. The comparison of the wave lengths of the spectral lines which characterize elements belonging to the same natural family may hereafter lead to interesting results, but at the present time it is difficult to institute such a comparison for the reason that we do not know all the lines which are produced by any one element. For the same reason it would probably be impossible at present to determine whether there is any law governing the wave lengths of the spectral lines belonging to the elements as regards their intervals or distribution over the spectrum. The conviction that precise knowledge of these and similar points must depend upon a knowledge of wave lengths and not merely of indices of refraction, has led me to make this first attempt to form a normal map of the spectrum. As a first attempt merely it is necessarily imperfect, but my object will be fully attained if I shall have succeeded in pointing out the path to be followed in the future discussion of the subject.

My grateful acknowledgments are due to Prof. J. E. Hilgard, under whose superintendence most of the curves which I have employed for interpolation have been drawn in the office of the Coast Survey. To Mr. S. P. Sharples I am also indebted for much assistance in the work of computation.

Cambridge, July, 1866.

Postscript.—Since the above was written I have received a second paper by Ditscheiner* on the wave lengths of the spectral lines, in which the author gives the results of a determination of the absolute value of the interval between two successive lines of the grating or ruled glass surface employed by him. When this value is used the wave lengths of Dβ and Dα become

* Sitzungsberichte der kaiserlichen Akad. der Wissenschaften, Band lii, 289.

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respectively, as measured by Ditscheiner, 590·53 and 589·89, which are 0·49 and 0·46 higher than those of Angström as given in Table I. Ditscheiner in this second paper has recomputed the table given in his first memoir. The results are much higher than those of Angström or those given in my reduction of Ditscheiner's first measurements, the average difference being about 0·4 of one unit. The close agreement of the two sets of results given in Table I appears to me a sufficient reason for adhering to the values of the wave lengths employed in this paper as data for interpolation.

Cambridge, August, 1866.

Art. II.—*John Francis Encke.**

John Francis Encke, born Sept. 23, 1791, was the youngest son but one of the deacon of the Jacobi Church in Hamburg. Four years after his birth his father died, leaving the care and the education of eight children to his mother, a lady of much worth, and happily possessed of great mental energy.

The first tutor of the boy was Mr. Hipp, a gentleman possessing considerable aptitude for mathematical teaching; and to his honor be it spoken, a man who rendered valuable pecuniary assistance to the orphan and moneyless family. Hipp continued this material encouragement to young Encke even after the time that he entered the College at Hamburg, well known as the Johaneum. At this College, then under the directorship of Gurlitt, who enjoyed a high reputation for classical learning, the boy-student rapidly advanced, and in addition to considerable ability in Latin composition, his knowledge of Greek was sufficient to enable him to translate and enjoy the Lyricks of Pindar. Notwithstanding, however, this early classical training, when the time came for his entrance at the University, Encke resolved henceforth to devote his attention mainly, if not exclusively, to the study of astronomy.

But here came a very formidable impediment; there were ample funds at the disposal of a poor clergyman's son for a theological career, but none for the prosecution of so unusual a study. Nevertheless, such was the acknowledged ability, and so determined was the inclination, of young Encke, that, as is happily not unusual in such cases, all the difficulties yielded at length to perseverance, and to his great joy, in Oct. 1811, he found himself at Göttingen, and a student under the celebrated Gauss.

The very newspapers of Hamburg were at that day compulsorily printed in French; as a condescension, however, or as an insult to the inhabitants, a German translation was added; in a

* From the Monthly Notices of the Astronom. Soc. of London, 1866, p. 129.

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like spirit even the university matricula of the old "Georgia Augusta" of Göttingen had the image and superscription of Jerome Buonaparte printed upon it. No wonder then that neither Gauss nor astronomy could retain the young student at his books, but, obeying the impulse which animated the whole heart of Germany, in the spring of 1813 he took up arms and marched to Hamburg for the rescue of his country from the domination of the French. After the re-occupation of Hamburg by the foreigner, Encke entered the Hanseatic Legion, then in process of formation in Holstein and Mecklenburg, and there he served as a sergeant-major in the horse artillery until July, 1814. In the autumn of this year he returned to Göttingen and to his astronomical pursuits, and for nearly twelve months continued a diligent student of subjects far more peaceable, and far more congenial to his turn of mind. Nevertheless the return of Napoleon from Elba once more finds him in a soldier's uniform, but now only for a short period, and, happily, for the last time. Waterloo and its consequences restored peace to France and to Europe, and young Encke, who in peace had no taste for soldiership and a uniform, returned, for the third time, to Göttingen and to Gauss. It was thus in the midst of these stirring and troublesome events, that the spirits of such men as Franz Encke and Wilhelm Struve were disciplined and matured.

While Encke was serving as a lieutenant of artillery in the Prussian fortress of Kolberg, he became acquainted with the celebrated Lindenau, at once astronomer and statesman, and after the completion of his studies under Gauss, he was appointed, by the influence of the former, an sssistant in the Observatory of Seeburg, not far from Gotha. In 1820 he became Vice-director, and in 1822 he was appointed Director, in the place of Lindenau, who returned to his political career.

It was at Seeberg that Encke commenced and completed his important work on the "Transits of Venus in 1761 and 1769," published at Gotha in 1822 and 1824. He also matured his investigation of the comet of 1680, and of the remarkable comet of short period which bears his name. Zach's Correspondence and Lindenau's Zeitschrift, about this period, contain many evidences of his talents and his industry. During his directorship of the Observatory at Seeberg he was elected an Honorary Associate of the Royal Astronomical Society, and at the time of his decease was the oldest foreign member on our list. In 1824 the Council of our Society awarded to Encke their gold medal for what Mr. Colebrooke, the President of that day, properly designated as "the greatest step that had been made in the astronomy of comets since the verification of Halley's Comet in 1759." Encke had long been on the track of his comet. In 1818 he had succeeded in identifying it with the Comet of Mechain and Mes-

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sier in 1786, and again with the comet discovered by Miss Herschel in 1795, and with the comet of Pons in 1805. The result of his investigations was, that this comet, which astronomers have agreed to designate as "Encke's Comet" (although he himself always modestly calls it the Comet of Pons), would make its appearance again in 1822, although it would not then be visible in Europe. Accordingly our Society had the gratification of presenting to Mr. Rümker their medal for its discovery at Paramatta in 1822, on the same day when they bestowed a similar mark of approbation, as we have already stated, on Encke himself, for its prediction.

It was in these Memoirs, that Encke signalized himself by his systematic and most successful application of the *principle of least squares* to a number of astronomical observations. For the method itself we are mainly indebted to Legendre and to Gauss, but for the first exhibition of its vast practical value, we are indebted to the example of Encke. His mind, indeed, seems to have been preëminently arithmetical, delighting in the orderly and systematic development of what otherwise and to many would seem an inextricable maze of figures. Those who knew him best consider that he probably injured the generality of his mathematical analysis by the fastidious care which he bestowed upon its symmetrical arrangement.

In 1825, at the recommendation of Bessel, Encke was appointed to the Directorship of the Observatory at Berlin; the Observatory itself was both improperly situated, and inadequately supplied with instruments, but ultimately, at the suggestion of Humboldt, a new Observatory was erected at the expense of the Prussian government, Encke superintending personally both its construction and its interior arrangements. And here, for eight or ten years after its completion, he continued with much assiduity to observe both with the Transit Circle and the Equatorial; but his natural tastes did not lie in instrumental observations, and after the discovery of numerous small planets by various observers, he devoted himself with much success to the investigation of planetary disturbances.

The labors of Encke in reference to the comet which bears his name have already been referred to. Having carefully taken into account the perturbing action of the planets on this comet during several successive periods, he established the remarkable fact that there is some extraneous cause in operation which continually diminishes the comet's periodic time. This is evidently the effect which would be produced if the comet suffered a resistance from moving in a very rare ethereal medium, and accordingly this is the explanation proposed by Encke, and at present generally accepted by astronomers.

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Encke has also, as already mentioned, devoted special attention to the subject of the perturbations of the Minor Planets.

In the Appendix to the *Berliner Jahrbuch* for 1837 and 1838, he expounds in detail the method of calculating these perturbations which had been long used by himself and other German astronomers, and which was originally given by Gauss. In this method the perturbations of the six elements of the orbit are computed for successive equal intervals of time by means of mechanical quadratures, and from the values of the elements thus found for any given time, the co-ordinates of the body at that time are determined.

Now this method, although a very beautiful one in theory, is attended with the disadvantage of requiring the determination of double the number of unknown quantities that are really wanted, and the calculations which must be gone through consequently become excessively long.

As the number of the known minor planets became larger, the want of a readier method of computing their perturbations became more and more pressing.

Encke was thus impelled to devise a mode of applying the method of integration by quadratures directly to the differential equations of motion of the disturbed body, and he published an account of this new method in the Proceedings of the Berlin Academy for 1851. In this Memoir he refers the place of the body to rectangular co-ordinates, and he determines the perturbations of its movements during successive short intervals of time by a direct computation of the changes produced in the three co-ordinates by the action of the disturbing planet.

He estimates that the labor of computation is reduced by the new method to less than one-half of that required by the method previously employed.

It should be remarked that Prof. G. P. Bond, in a paper which was communicated to the American Academy of Arts and Sciences in 1849, had already briefly explained a method of calculating perturbations exactly similar in principle to that of Prof. Encke, but the latter was totally unaware of the existence of this paper when he published his own Memoir, which enters much more fully into the practical details of the method, and gives greater prominence to the importance of it as applied to the case of the minor planets.

By astronomers of the present day it is possible that Encke may be most highly estimated for the vast improvements which he introduced into the Berlin Ephemeris. The history of astronomical ephemerides is not a little varied and curious; a concise account of it will be found in the fourth volume of the Memoirs of the Royal Astronomical Society, on the occasion of the council of the Society presenting Encke, through their President,

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with a gold medal, for the part which he had taken in the improvement of the Berlin Ephemeris. Our own Nautical Almanac, at that day, viz. in 1830, had fallen or had remained greatly behind the requirements of astronomers; but in speaking of the merits of the foreign Ephemeris, the report of the Council runs as follows: "A gold medal has been voted to Professor Encke for the superb *Ephemeris of Berlin*. It would be superfluous to dwell upon the merits of this well-known work, which, far outstripping all rivalry, must be considered as the only Ephemeris on a level with the present wants of the sciences." On presenting the medal, Sir James South, the President, adds, "With the *Berlin Ephemeris*, an observatory scarcely wants a single book; without it, every one." It would, however, be disloyal, though in any other aspect it may be needless, not to add that what has just been said of the Berlin Ephemeris of 1830, may with equal truth be predicated of the Nautical Almanacs from 1834 to the present date; nevertheless the first impulse came from Encke and Berlin.

Many other labors of Encke may also be found in the Memoirs and Monthly Reports of the Berlin Academy, in the Astronomische Nachrichten, and in four volumes of the Berlin Observations. He is also well known by the publication of several excellent speeches, and especially for a memorable *éloge* on the celebrated Bessel.

Encke visited England in the autumn of 1840, in order to be present at the meeting of the British Association, and for the purpose of inspecting the English Observatories. His account of that journey is a testimony of the deep and pleasing impression which his hearty reception in England left upon his memory.

In 1859 Encke suffered from an apoplectic fit, and foreseeing the commencement of disease of the brain, he obtained leave of absence from his Observatory in the spring of 1863. In the autumn of the same year, finding a recurrence of the same symptoms, and knowing what they implied, with a brave heart, the now aged man explained his forebodings to a physician, and at once placed himself under his care in an institution for diseases of the brain at Kiel. At the commencment of 1864 he requested permission to be relieved from all astronomical work, and until the time of his decease, continued to live in a quiet, happy state of mind, in the midst of his family, at Spandau, near Berlin.

Encke, during the forty years of his professorship at Berlin, impressed the form and bent of his mind upon many pupils, who have ably contributed their share in the progress of astronomical knowledge. There is no greater proof of the real worth of a teacher, than when his pupils speak well and lovingly of him. They see the man in his weakness and in his strength. So it fared with Encke. They bear strong and uniform testi-

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mony to his eminent frankness and truthfulness; his labors, they say, were incessant, his recreations few; he was simple in his manners, and in all his habits temperate. Towards his coadjutors and assistants he showed a severe judgment, but he set them a severer example. A man such as this, absorbed in his work, and shutting himself away from the outer world, was likely to be sometimes abrupt, or laconic, or even incautious, in his utterances; these utterances, from their bluntness or their truthfulness, occasionally gave offense, and involved Encke in trouble. As age, however, grew upon him he became more gentle in his manners, and softer in his address; and in the presence of those whom he knew and trusted, the old man would sometimes review his own life, and urge his favorite pupils to draw from his own experience lessons of moderation and self-restraint, both in passing their judgments on the labors of others, and in the amount of labor which they felt it their duty to exact from themselves.

There occurs but one more question regarding this great and venerable man; the writer of this memoir gladly adopts this language, *great and venerable*, because they are the very words selected by men who served him long and who knew him well, and who are themselves doing good public service in their own day. It is well known that great theological activity, not to say theological strife, surrounded Encke and every other intellectual thinker in Germany; it may not, perhaps, concern us, simply as students in Astronomy, but it cannot fail to interest us as men, to know what effect this independence of thought and boldness of expression had upon the spirit of a man, whose name will for ever be associated with some of the noblest and furthest-reaching efforts of the human mind. In reply to this question, we are told by those who knew him intimately, that Encke retained through life the strength and simplicity of his early faith; and we also learn that he was heard repeatedly to say, that one of the greatest pleasures of his life was derived from the fact, that one of his sons had become a minister of the Gospel. C. P.

ART. III.—*Sketch of the Geology of Northeastern Dakota, with a notice of a short visit to the celebrated Pipestone Quarry;* by F. V. HAYDEN.

THE object of this note is simply to record some observations on the geology of Northeastern Dakota, made by me in October last, together with an account of a short visit to the celebrated Pipestone quarry. No positive inference is drawn as to the age of the rocks in which the pipestone layer is located, from the fact that no well-defined organic remains could be found. Therefore certain facts are noted down with the hope that they may

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hereafter aid in the solution of the problem of their age, inasmuch as their geographical distribution seems to be quite extended.

In October last, after my return from a tour of exploration to the "Mauvaises Terres" or "Bad Lands" of White river, I took advantage of an opportunity that presented itself to visit some portions of Dakota Territory on the north side of the Missouri river not hitherto examined by me. I there made my starting point the village of Yankton, the capital of Dakota Territory, located on the Missouri, about twelve miles above the mouth of the James. At this point we observed a large exposure of the yellow calcareous marl beds of No. 3, Niobrara Division, forming along the river nearly vertical bluffs, extending sometimes several miles. The rock varies in texture from a nearly white, soft chalk, much like our chalk of commerce, to a somewhat compact limestone which is used for burning into lime and for building purposes. Thick beds of this chalk present a marked rust color from the presence of a greater or less amount of the peroxyd of iron; otherwise it could hardly be distinguished from the chalk of Europe, and without doubt would serve the same economical purposes. The organic remains found here are not very numerous in species. The most abundant shell is the *Ostrea congesta* Conrad, which seems to have been as gregarious and to have aggregated together much in the same way as the little oyster which is exposed when the tide recedes along the shores of the Sea Islands of South Carolina. Near the base of No. 3, there are layers of rock several feet in thickness, made up almost entirely of one or more species of *Inoceramus*, one of which has been identified as *I. problematicus*. The fish remains are quite numerous, diffused throughout the rock. Fragments, consisting of jaws, ribs and scales, are found in the greatest abundance, and Mr. Propper, a resident of Yankton has succeeded in securing some nearly perfect specimens (undescribed) from the quarries there. This group of rocks extends for four hundred miles along the Missouri river, and I am convinced that when carefully studied, it will be found to represent the White Chalk beds of Europe, and be employed for similar economical purposes.

The Cretaceous rocks of the Missouri river have been numbered in the order of superposition, Nos. 1, 2, 3, 4, 5, and all of these divisions have been located in the geological scale by the unmistakable evidence of their organic remains. We find therefore that this portion of Dakota is occupied exclusively, or nearly so, by the middle member of the Cretaceous series. The soft and yielding nature of No. 3 is well shown by the topographical features of the country, where all the slopes are gentle in their descent, and for the most part covered with a thick

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growth of grass; for the soil which is composed of the eroded materials of this group is quite fertile, and in ordinary seasons produces excellent crops, and is especially adapted to the growth of cereals.

From Yankton our course was nearly north, up the west side of James river. Our path led over a gently rolling prairie for sixty-five miles, with not a tree or a bush to greet the eye. There were no cut bluffs along the little streams over which we passed; the sides of the hills bordering the valleys sloping at a very moderate angle, and being covered with a thick growth of grass. No rocks were seen in place until we arrived at Fort James, about twelve miles below the mouth of Firesteel creek, a branch of James river. Erratic rocks of all sizes and texture were visible on the surface everywhere, more especially in the valley of James river and its tributaries.

At this point on James river, uncovered by the scooping out of the valley, is a large exposure of reddish variegated quartzites, differing somewhat in structure and appearance from any rocks hitherto observed by me on the Upper Missouri. They cover a considerable area in the valley of the James at certain localities, but nowhere are they exposed at a thickness of more than twenty or thirty feet. Indeed they have been much worn by water, so that they project above the surface in large square masses, suggesting to one in the distance a village of log houses.

The rocks are mostly reddish and flesh-colored quartzites, so compact that the lines of stratification are nearly obliterated. They also appear to be metamorphic. There is, however, a horizontal as well as a vertical fracture, and the horizontal fracture breaks across what appear to be original laminæ of deposition. These lines or bands are seldom horizontal; but much waved and inclined, as if the materials had been deposited in shoal or troubled waters. The illustrations of ripple or wave markings in these rocks are very numerous and beautiful. There is considerable variety in the texture of the rock; some of it is a very fine, close-grained quartzite, so that when worn by water it presents a smooth glistening surface like glass. Again it is filled with small water-worn pebbles, forming a fine pudding stone; again there are layers of siliceous sandstone, which separate into slabs varying from one-fourth of an inch to several inches in thickness. This rock is very useful for building purposes, and has been employed at this point by the U. S. army officers in erecting the numerous buildings that constitute the fort. I looked diligently wherever the rock had been quarried, for some traces of organic remains, but none were visible. Resting upon the quartzite at this locality, is a bed of black plastic clay, precisely like No. 2 Cretaceous, as seen along the Missouri river near the mouth of the Vermilion. I found no fossils in this

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rock, but there were numerous specimens of selenite in crystals, which characterize it in other localities. Resting on No. 2 is the Chalky marl of No. 3, not differing in structure from the same rock before described as occurring at Yankton on the Missouri river. It here contains an abundance of its characteristic fossil, *Ostrea congesta.* The thickness exposed is about fifty feet, but from an examination of the slope above, I estimated its entire thickness at this point at from 80 to 100 feet.

The formations at this locality, in descending order, are as follows: *a.* Yellow chalky marl No. 3; *b.* Black plastic clay with selenite crystals, undoubtedly No. 2; *c.* Reddish and rose-colored quartzites.

From Fort James we again proceeded across the undulating prairie, in a direction a little south of east, about 65 miles, to Fort Dakota, at Sioux Falls, on the Big Sioux river. Nothing of especial interest, in a geological point of view, met our eye except a small exposure of the reddish quartzite in the valley of Vermilion river. The soil of the prairie over which we passed, and also the superficial deposits as shown along the streams, gave unmistakable evidence that the surface features of all this region are due to the wearing away of the Cretaceous rocks Nos. 2 and 3, and that they are the immediate underlying formations. The most characteristic features which met the eye everywhere, were the boulders which cover large areas so thickly as to render cultivation impossible until they are removed. These rocks, however, will be found to be very useful to future settlers for building and other economical purposes.

At Sioux Falls there is a remarkable exhibition of the same red and variegated quartzites described at James river. They are here exposed only in the valley of the river by the removal of the superincumbent Cretaceous rocks. The falls are five or six in number, extending a distance of half a mile, and have a descent of 110 feet in all, forming the most valuable water power I have ever seen in the west. About ten feet from the top of the rocks as seen at this locality, is a layer of steatitic material, mottled, gray and cream-color, very soft, about 12 inches thick, which is used sometimes for the manufacture of pipes and other Indian ornaments. When the quartzites have been subjected to the attrition of water, they present the same smooth glassy surface as before mentioned. There are also beds of pudding stone, and the most beautiful illustrations of wave and ripple markings that I have ever observed in my geological explorations.

I was unable to discover any well defined fossils, but wherever the surfaces of the rocks had been made smooth by the attrition of water, quite distinct rounded outlines of what appeared to be bivalve shells could be seen, so numerous that the rocks must have been charged with them. The matrix is so

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close grained and hard, that on breaking the rock no trace of the fossil could be found. I am confident, however, that the rock is filled with organic remains, but they cannot now be separated from the matrix so as to be identified.

From Sioux Falls to the celebrated Pipestone quarry, the distance is just 40 miles, measured with an odometer. Direction a little east of north. We passed over a similar undulating prairie, with but one small tree along the route, and but one rock exposure, and that occurs about four miles south of the quarry. The rock is a very hard quartzite, composed largely of water-worn pebbles, quartz, jasper, small clay nodules, chalcedony; some of the rock is a quartzose sandstone, other portions are fine grained siliceous rock. It lies in regular layers or beds, dipping at an angle of about 5°, 30° S. of E.*

On reaching the source of the Pipestone creek, in the valley of which the Pipestone bed is located, I was surprised to see how inconspicuous a place it is. Indeed, had I not known of the existence of a rock in this locality so celebrated in this region, I should have passed it by almost unnoticed. A single glance at the red quartzites here, assured me that these rocks were of the same age with those before mentioned at James and Vermilion rivers, and at Sioux Falls. The layer of Pipestone is about the lowest rock that can be seen. It rests upon a gray quartzite, and there are about five feet of the same gray quartzite above it, which have to be removed with great labor before the Pipestone can be secured. About 300 yards from the Pipestone exposure is an escarpment, or nearly vertical wall of variegated quartzite, extending directly across the valley. Each end of the wall passes from view beneath the superficial covering of the prairie. It is about half a mile in length. About a quarter of a mile farther up the valley there is another small escarpment, so that the entire thickness of the rock exposed at this point is about 50 feet. Not a tree can be seen; only a few small bushes growing among the rocks. There is a little stream of clear, pure water flowing from the rocks, with a perpendicular fall of about 30 feet, forming a beautiful cascade. The evidences of erosion were very marked, and the question arose—how could all the materials which must once have existed here joined on to these walls, have been removed, except by a stream much larger and more powerful in its erosive action than the one at present flowing here? There is a slight inclination of the beds from 1° to 3°, about 15° S. of E.

About 200 yards southeast of the quarry are five massive boulders, composed of a very coarse flesh-colored feldspathic granite, very much like that which forms the nucleus of the Black Hills.

* I am greatly indebted to Col. Knox, commandant of Fort Dakota, at Sioux Falls, for important facilities in my examinations.

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The first detailed account of the Pipestone quarry that I have been able to find, is that of Catlin, in this Journal, [1], xxxviii. In Nicollet's excellent report there is a much more careful and accurate description of the rock and the locality, but neither of these gentlemen hint at the probable geological age. The first attempt to determine the age of the rocks in which the Pipestone is located, was made by Prof. Hall, in a paper read before the American Philosophical Society not long since. In that paper he regards them as of the same age with the Huronian rocks of Canada and Lake Superior.

At the time Mr. Catlin made his visit to the quarry he sent a portion of the pipestone to Prof. C. T. Jackson, of Boston, for analysis. Prof. J. gave it the name of Catlinite, with the following composition:

Water,	8·4
Silica,	48·2
Alumina,	28·2
Magnesia,	6·0
Peroxyd of iron,	5·0
Oxyd of manganese,	0·6
Carbonate of lime,	2·6
Loss (probably magnesia),	1·0
	100

The Pipestone layer, as seen at this point, is about 11 inches in thickness, only about 2½ inches of which are used for manufacturing pipes and other ornaments. The remainder is too impure, slaty, fragile, &c. This rock possesses almost every color and texture, from a light cream to a deep red, depending upon the amount of peroxyd of iron. Some portions of it are soft, with a soapy feel, like steatite, others slaty, breaking into thin flakes; others mottled with red and gray. A ditch from four to six feet wide and about 500 yards in length, extending partly across the valley of Pipestone creek, reveals what has thus far been done in excavating the rock. There are indications of an unusual amount of labor on the part of the Indians in former years to secure the precious material.

This rock has been used for many years past by the Indians of the Northwest for the manufacture of pipes, and it was formerly the custom of some of the tribes to make the locality an annual visit to secure a portion of the precious material. They placed a higher value on the rock, because, while being so firm in texture it is so easily wrought, and because they could make far more beautiful and showy pipes than from any other material known to them. Besides, this was and is now, the only locality from whence the true pipestone can be obtained, and the labor is so great in throwing off the five feet of solid quartz-

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ite that rests upon it, that the rock has always been rare. For a mile or two before reaching the quarry the prairie is strewed with fragments that have been cast away by pilgrims.

Nearly all of our writers on Indian history have invested this place with a number of legends or myths. They have represented the locality as having been known to the Indians from remote antiquity. All these notions, I am convinced, will disappear defore the light of a careful investigation of the facts. It is quite probable that the rock has not been known to the Indians more than eighty or one hundred years, and perhaps not even as long a period. I could not find a trace of a stone implement in the vicinity, nor could I hear that any had ever been found; and indeed nothing could be seen that would lead one to suppose that the place had been visited for a longer period than fifty years. All the excavations could have been made within that time. There are many rude iron tools scattered about, and some of them were taken out of the ditch last summer in a complete state of oxydation.

Again, it does not appear that in the mounds which have been opened in the Mississippi valley so extensively, any trace of this rock has ever been found. It is well known that the pipe is the most important of the dead man's possessions and is almost invariably buried with the body, and if a knowledge of this rock had extended back into the stone age, it is almost certain that some indications of it would have been brought to light in the vast number of mounds that have been opened in the valley of the Mississippi. Pipes and other ornaments, made from steatite, have been in use among Indians from the earliest indications of their history, and they are still manufactured from this material on the Pacific coast.

Now the question arises as to the age of the rocks we have attempted to describe and which include the pipestone layer. Owing to the absence of well defined organic remains, the problem becomes a difficult one. Their exceedingly close-grained, compact, apparently metamorphic character, would direct one's attention to the older rocks, perhaps some member of the Azoic series; but if the impressions seen at Sioux Falls are those of bivalve shells, we must look higher in the scale. But in order that we may arrive at an approximate conclusion, let us look at the geology of the surrounding country.

We already know that the limestones of the upper Coal Measures are exposed at Omaha City, and continue up the Missouri river to a point near De Soto, almost twenty miles farther, where they pass from view beneath the bed of the river. Overlapping them is a coarse sandstone composed of an aggregation of particles of quartz cemented with the peroxyd of iron. This assumes every color from a deep dull red to a nearly white. The layers

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of deposition are very much inclined and distorted. Near Blackbird hill numerous dicotyledonous leaves have been found, and many of these plants occur in a quartzite so close-grained that the lines of stratification are nearly or quite obliterated, yet the impressions are distinct. This quartzite forms a valuable quarry near Sioux City. The coal seam included in this formation, (Lower Cretaceous, No. 1) crops out forty miles up the Big Sioux, or within sixty miles of Sioux Falls. Between Sioux City and Yankton we have at least three members of the Cretaceous series. Near Fort James we find that two members of the Cretaceous series (Nos. 2 and 3) rest upon the quartzites. The surface features of the whole country, with the soil and drift, indicate that the immediate underlying rocks are of Cretaceous age? Is it not possible therefore, that the quartzites that include the pipestone bed, belong to the supra-carboniferous, Triassic perhaps, or even to an extension downward of Cretaceous No. 1?

Prof. Hall, in an interesting geological memoir, read recently before the American Philosophical Society, gives an account of a tour into Western Minnesota, and many of the rock exposures which he describes must be of the same age with those noticed in this paper. He seems to have proceeded west from St. Paul to St. Peters and Fort Ridgely on the Minnesota river. From Fort Ridgely he continued west to Lake Shetek, which is not more than forty miles from the pipestone bed. Prof. Hall describes a wall of red quartzite at this locality, which he thinks is of the same age and character with that at Pipestone creek. I am convinced that not only the rock at Lake Shetek, but at many other localities which he describes with great care, are of the same age. I was informed by intelligent land surveyors in Dakota and Minnesota, that these red quartzite exposures extend very far to the north. Prof. Hall regards these quartzites as of the age of the Huronian series. His opportunities for tracing these rocks from the north and east were excellent, and his opinion is entitled to great weight.

Acad. Nat. Sci. Philadelphia, Nov. 10, 1866.

Art. IV.—*New Classification of Meteorites, with an Enumeration of Meteoric Species;* by Charles Upham Shepard.

The arrangement here proposed differs so widely from the two formerly put forth by me, as to be really new. The changes introduced will, I trust, appear as flowing naturally from the recent progress of the study. The localities by which the system is illustrated are such as are represented in my collection, now deposited in Amherst College. A number of localities found on my previous lists as well as upon those of others, are omitted,

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either because a degree of doubt hangs over their meteoric origin, or for the reason that they have suffered artificial alteration, or been too largely exposed to terrestrial decomposition.

Classification of Meteorites.

CLASS I. **LITHOLITES.** Stoney. (Λίθος, *a stone.*)	Sub-Class I. Eucritic. *Crystalline: earthy individuals distinct.* (Εὐκρίτος, *distinct.*)	Ord. 1st. *Feldspathic.* Contains one or more species of feldspar. Ord. 2nd. *Augitic.* Contains augite.
	Sub-Class II. Dyscritic. *Earthy individuals indistinct.* (Δύσκρίτος, *indistinct.*)	Ord. 1st. *Psammitic.* (Ψάμμος, *sand.*) Has the structure of sandstone. Ord. 2nd. *Howardic.* Compactly massive. Ord. 3rd. *Oolitic.* With oolitic grains. Ord. 4th. *Porphyritic.* Sub-porphyritic. Ord. 5th. *Basaltic.* Trappean.
	Sub-Class III. Anthracic. *Black.* (Ἄνθραξ, *coal.*)	Ord. 1st. *Atalene.* (Ἀτάλός, *soft.*) Friable. Ord. 2nd. *Anatalene.* (α, *privative* and ἀτάλός, *firm.*) Firm.
CLASS II. **LITHOSIDERITES.** Stone and iron, mixed. (Λίθος & Σίδηρος, iron.)	Sub Class I. Pleiolithic. *More than half stoney.* (Πλείων, *more.*)	Ord. 1st. *Stigmatic.* (Στίγμα, *a spot.*) Iron in round spots.
	Sub-Class II. Meiolithic. *Less than half stoney.* (Μείων, *less.*)	Ord. 1st. *Mignumic.* (Μίγνῦμί, *to mix.*) Stone and iron much mixed.
CLASS III. **SIDERITES.** Chiefly iron.	Sub-Class I. Psatharic. *Brittle.* (Ψαθαρός, *brittle.*)	Ord. 1st. *Chalyptic.* (Χάλυψ, *steel.*) Steel-like.
	Sub-Class II. Apsatharic. *Tough.* (Ἀψαθαρός, *tough.*)	Ord. 1st. *Agrammic.* Without lines when etched. Ord. 2nd. *Sporagrammic.* With scattered lines. Ord. 3rd. *Microgrammic.* Lines very small. Ord. 4th. *Eugrammic.* Lines distinct. Ord. 5th. *Megagrammic.* Lines coarse. Ord. 6th. *Tæniastic.* (Ταινία, *a rib-and.*) Banded. Ord. 7th. *Nephelic.* (Νεφέλη, *a cloud.*) Clouded.

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CLASS I. LITHOLITES.

SUB-CLASS I. EUCRITIC.

ORDER 1st. *Feldspathic.*

1. Stannern, Moravia, May 22, 1808.
2. Juvenas, France, June 15, 1821.
3. Jonzac, France, June 13, 1819.
4. Mässing, Bavaria, Dec. 13, 1803.
5. Petersburg, Tenn., U. S. A., Aug. 5, 1855.
6. Bialistock, Poland, Oct. 17, 1827.
7. Nobleboro, Maine, U. S. A., Aug. 7, 1823.
8. Manegaon, July 26, 1843.
9. Luotolaks, Finland, Dec. 13, 1813.

ORDER 2d. *Augitic.*

1. Chassigny, France, Oct. 3, 1815.
2. Bishopsville, S. Carolina, U. S. A., March 25, 1843.
3. Ensisheim, France, Nov. 7, 1492.
4. Shalka, India, Nov. 30, 1850.

SUB-CLASS. II. DYSCRITIC.

ORDER 1st. *Psammitic.*

1. Erxleben, Prussia, April 15, 1815.
2. Bethlehem, New York, U. S. A., Aug. 11, 1859.
3. Kleinwenden, Prussia, Sept. 16, 1843.
4. Simbirsk, Russia.
5. Pillistfer, Russia, Aug. 8, 1862.
6. Klein Menow, Mechlenburg, Oct. 7, 1861.

ORDER 2nd. *Howardic.*

1. Paulograd, Russia, May 19, 1826.
2. Zaborzika, Russia, April 10, 1818.
3. Mauerkirchen, Austria, Nov. 20, 1768.
4. Oesel, Baltic Sea, May 13, 1855.
5. Charkow, Russia, Oct. 13, 1787.
6. Linum, Prussia, Sept. 5, 1854.
7. Castine, Maine, U. S. A., May 20, 1848.
8. Alboreto, Italy, July, 1766.
9. Futtehpur, India, Nov. 30, 1822.
10. Kakova, Hungary, May 19, 1858.
11. Aumières, France, June 4, 1842
12. Utrecht, Holland, June 2, 1843.
13. Lucé, France, Sept. 13, 1768.
14. Milena, Croatia, April 26, 1842.
15. Slobodka, Russia, Aug. 10, 1818.
16. New Concord, Ohio, U. S. A., May 1, 1860.
17. Girgenti, Sicily, Feb. 10, 1853.
18. Uden, Holland, June 12, 1840.
19. Buschof, Russia, June 2, 1863.
20. Angers, France, June 3, 1822.
21. Kuleschofka, Russia, Mar. 12-13, 1811.
22. Lissa, Bohemia, Sept. 3, 1808.
23. Bachmut, Russia, Sept. 15, 1814.
24. St. Denis, Belgium, June 7, 1855.
25. Apt, France, Oct. 8, 1803.
26. Linn, Iowa, U. S. A., Feb. 25, 1847.
27. Politz, Russian Germany, Oct. 13, 1819.
28. Nashville, Tenn., U. S. A., May, 9, 1827.
29. Forsyth, Georgia, U. S. A., May, 8, 1829.
30. Deal, New Jersey, U. S. A., Aug. 14, 1829.
31. Tirlemont, Belgium, Dec. 7, 1863.
32. High Possil, Scotland, April 5, 1804.
33. Moradabad, India, Feb. 1808.
34. Durala, India, Feb. 18, 1815.
35. Yorkshire, Eng., Dec. 13, 1795.
36. Darmstadt, Hessia, 1815.

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37. Nerft, Russia, April 12, 1864.
38. Macerata, Italy, May 8, 1846.
39. Dhurmsäla, India, July 14, 1860.
40. Wessely, Moravia, Sept. 9, 1831.
41. Sales, France, March 8, 1798.
42. Favars, France, Oct. 21, 1844.
43. Heredia, Costa Rica, Apr. 1, 1857.
44. Vouillé, France, May 13, 1831.
45. Toulouse, France, April 10, 1812.
46. Constantinople, Turkey, June, 1805.
47. Grüneberg, Silesia, Prussia, Mar. 22, 1841.
48. Charsonville, France, Nov. 23, 1810.
49. Aigle (L'Aigle), France, April 26, 1803.
50. Charwallas, India, June 12, 1834.
51. Berlanguillas, Spain, July 8, 1811.
52. Goruckpore, India, May 12, 1861.
53. Macao, Brazil, Nov. 11, 1836.
54. Eichstadt, Bavaria, Feb. 19, 1785.
55. Agen, France, Sept. 5, 1814.
56. Château-Renard, France, June 12, 1841.
57. Doroninsk, Russia, Apr. 10, 1805.
58. Killeter, Ireland, April 29, 1844.
59. Shytal, India, Aug. 11, 1863.
60. Lixna, Russia, July 12, 1820.
61. Honolulu, Sandwich Isl'ds, Sept. 14, 1825.
62. Allessandria, Piedmont, Feb. 2, 1860.

ORDER 3rd. *Oolitic.*

1. Gutersloh, Prussia, April 17, 1851.
2. Nanjemoy, Maryland, U. S. A., Feb. 10, 1825.
3. Benares, India, Dec. 13, 1798.
4. Pulaski, Missouri, U. S. A., Feb. 13, 1839.
5. Nellore, India, Jan. 23, 1852.
6. Ausson, France, Dec. 9, 1858.
7. Timochin, Russia, March 13–25. 1807.
8. Trenzano, Italy, Nov. 12, 1856.
9. Pegu, India, Dec. 27, 1857.
10. Cereseto, Piedmont, July 17, 1840.
11. Esnande, France, Aug. 1837.
12. Poltawa, Russia, anterior to 1838.
13. Zebrak, Bohemia, Oct. 14, 1824.
14. Ohaba, Transylvania, Oct. 10–11, 1857.
15. Casignano, Parma, Italy, April 19, 1808.

ORDER 4th. *Porphyritic.*

1. Assam, India. Found 1846?
2. Mëzo-Madaras, Transylvania, Sept. 4, 1852.
3. Chandakapoor, India, June 6, 1838.
4. Weston, Conn., U. S. A., Dec. 14, 1807.
5. Agra, India, March 28, 1860.
6. Siena, Tuscany, Italy, June 16, 1794.
7. Harrison, Kentucky, U.S.A., Mar. 26, 1859.
8. Richmond, Virginia, U.S.A., June 14, 1829.
9. Limerick, Ireland, Sept. 10, 1813.
10. Parnallee, India, Feb. 28. 1857.
11. Nulles, Spain, Nov. 5, 1851.
12. Abkurpore, India, April 18, 1838.
13. Cabarrus, N. Car., U. S. A., Oct. 31, 1849.
14. Okniny, Russia, Dec. 27, 1833.
15. Tabor, Bohemia, July 3, 1753.
16. Blansko, Moravia, Nov. 25, 1833.
17. Seres, Turkey, June, 1818.
18. Luponnas, France. Sept. 7, 1753.
19. Barbotan, France, July 24, 1790.
20. Tipperary, Ireland, Aug. 1810.
21. Bremevörde, Hannover, May 13, 1855.

ORDER 5th. *Basaltic.*

1. Chantonnay, France, Aug. 5, 1812.
2. Renazzo, Italy, Jan. 15, 1824.
3. Segowlee, India, March 6, 1853.
4. Mainz, Hessia. Found in 1852.

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Sub-Class III. Anthracic.

Order 1st. *Atalene.*

1. Alais, France, March 15, 1806.
2. Orguiel, France, May 14, 1864.
3. Charleston, S. C., U. S. A., Nov. 16, 1857.

Order 2d. *Anatalene.*

1. Cold Bokkeveldt, Africa, Oct. 13, 1838.
2. Kaba, Hungary, April 15, 1857.
3. Grosnja, Caucasus, Russia, June 16, 1861.
4. Simonod, (Ain) France, Nov. 13, 1835.

Class II. Lithosiderites.

Sub-Class I. Pleiolithic.

Order 1st. *Stigmatic.*

1. Hainholz, Westphalia. Found 1856.
2. Sierra de Chaco, Atacama, S. A. Found in 1862.

Sub-Class II. Meiolithic.

Order 1st. *Mignumic.*

1. Atacama, S. A. Found 1827.
2. Rittersgrün, Saxony. Found 1861.
3. Steinbach, Saxony. Found 1751
4. Krasnojarsk, Siberia. Found 1776.
5. Taney, Missouri, U. S. A. Found in 1856.
6. Newton, Ark., U. S. A. Found in 1860.

Class III. Siderites.

Sub-Class I. Psatharic.

Order 1st. *Chalyptic.*

1. Rutherford, N. Car., U. S. A. Found in 1856.
2. Niakornak, Greenland.
3. Newstead, Roxburgshire, Scotland. Found in 1861.
4. Otsego, N. Y., U. S. A. Found in 1845.

Sub-Class II. Apsatharic.

Order 1st. *Agrammic.*

1. Scriba, N. York, U. S. A. Found 1814.
2. Babb's Mill, Tenn., U. S. A. Found 1842.
3. Smithland, Kentucky, U. S. A. Found 1840.
4. Botetourt, Virginia, U.S.A. Found anterior to 1845.
5. Oktibbeha, Miss., U. S. A. Found in an Indian mound in 1856.
6. Wöhler's unknown locality.
7. Tuczon, Sonora. Found 1850.

Order 2d. *Sporagrammic.*

1. Chester, S. Car., U. S. A. Found 1847.
2. Walker, Alabama, U. S. A. Found in 1832.
3. Dacotah, U. S. A. Found 1863.
4. Rasgata, New Granada. Found 1823.

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ORDER 3rd. *Microgrammic.*

1. Santa Rosa, (Coahuila) Saltillo, Mex. Found 1850.
2. Tocavita, near Tunga, New Grenada. Found 1823.
3. Braunau, Bohemia. Fell July 14, 1847.
4. Salt River, Kentucky, U. S. A. Found 1850.
5. Senegal, Africa. Found 1763.
6. Tucuman, Otumpa, Arg.Rep., S.A. Found 1788.
7. Bitburg, (Eifel) Prussia. Found 1814.
8. Bonanza, Mexico. Found 1865.

ORDER 4th. *Eugrammic.*

1. Oxtlahuaca, Mex. Found 1784.
2. Toluca, Mexico. Found 1784.
3. Mani (Toluca valley). Wöhler's 19 lb. mass.)
4. Ruff's Mountain, S. Car., U. S. A. Found 1850.
5. Marshall, Kentucky, U. S. A. Found 1856.
6. Schwetz, Prussia. Found 1850.
7. Cranbourne, Australia. Found 1861.
8. Robertson, Tenn., U.S.A. Found 1860.
9. Seneca Falls, N. York, U. S. A. Found 1850.
10. Orange River, Africa. Found 1856.
11. Oaxaca, Mexico. Found 1843.
12. Burlington, N. York, U. S. A. Found 1819.
13. Tula, Russia. Found 1846.
14. Wayne, Ohio, U. S. A. Found 1849.
15. Lenarto, Hungary. Found 1815.
16. Bohumilitz, Bohemia. Found 1829.
17. Texas (Red River), U.S.A. Found 1814.
18. Madoc, Canada. Found 1854.
19. Caillé, France. Found 1828.
20. Nebraska, U.S.A. Found 1856.
21. Lockport, N. York, U.S.A. Found 1818.
22. Oldham, Kentucky, U. S. A. Found 1860.
23. Durango, Mexico. Found 1811.
24. Carthage, Tenn., U.S. A. Found 1845.
25. Oregon, U. S. A. Found 1845.
26. Bahia, (Bendigo) Brazil.
27. Agram, Croatia. Fell May 26, 1751.
28. Ellogen, Bohemia. Found 1811.
29. Lion River, Africa. Found 1853.
30. Putnam, Georgia, U.S.A. Found 1839.
31. Aeriotopos,* near Denver City, Colorado. Found in 1866.
32. Asheville, N. Car., U.S.A. Found in 1839.
33. Guildford, N.Car., U.S.A. Found in 1828.
34. Tazewell, Tenn., U. S. A. Found in 1853.
35. Oberrkirchen, Nassau. Found in 1863.
36. Dickson, Tenn., U. S. A. Fell July 30, 1835.

ORDER 5th. *Megagrammic.*

1. Arva, Hungary. Found 1844.
2. Sarepta, Russia. Found 1854.
3. Zaccatécas, Mexico. Found 1792.
4. DeKalb, Tenn. Found 1845.
5. Cocke, (Sevier) Tenn., U. S. A. Found 1840.
6. Heywood, N. Car., U.S.A. Found 1854.

* Αηριος, *lofty* and τοπος, *place*, from its being found over 8,000 feet above the sea.

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ORDER 6th. *Tæniastic.*

1. Cape of Good Hope, Africa. Found 1801.

ORDER 7th. *Nephelic.*

1. Black Mountain, S. Car., U. S. A. Found 1835.
2. Seeläsgen, Prussia. Found 1847.
3. Nelson, Kentucky, U. S. A. Found 1856.
4. Union, Georgia, U. S. A. Found 1853.
5. Pittsburg, Penn., U. S. A. Found 1850.
6. Tabarz, Thuringia. Found 1854.

APPENDIX TO SUB-CLASS II. Markings not ascertained.

1. Savisavik, Greenland. Found 1850 ?
2. Benton, Texas, U. S. A. Found 1856.
3. Brazos, Texas, U. S. A. Found 1856.

Total number of localities in the collection, 211.

METEORIC MINERALS.*

1. CHAMASITE, (*Reichenbach.*) Fe, or variable mixtures of Fe and Ni up to 23 p. c. of the latter.
2. TÆNITE, (*Reichenbach.*) $Fe^x Ni^x$. ($Fe^4 Ni^2$. ?)†
3. OKTIBBEHITE, (*Shepard.*) Fe Ni.
4. SCHREIBERSITE, (*Haidinger.*) $Fe^x Ni^x P^x$ ($Fe^4 Ni^2 P$. ?)‡
5. RHABDITE, (*Reichenbach.*) $Fe^x Ni^x P^x$.
6. CHALYPITE, (*Shepard.*) $Fe^x C^x$. Forchhammer obtained as a leading constituent of the Niakornak Iron a hard, brittle, cast-iron like compound of iron and carbon in proportions of from 7·23 to 11·06 p. c. of carbon, which would indicate the formula of Fe^2C for this species.
7. FERROSILICITE, (*Shepard*). Fe^6 Si (Si being 22).
8. TROILITE, (*Reichenbach*). $Fe^7 S^8$ (or Fe 62·07, S 37·93).
9. GRAPHITOID, (*Shepard*). $Fe^x C^x$ (nearly pure C).
10. KABAITE, (*Shepard*). $C^x H^x O^x$ (meteoric petroleum).
11. CHROMITE. $\dot{F}e\,\ddot{C}r$ (with traces of $\dot{M}g$).
12. QUARTZ. $\ddot{S}i$.
13. OLIVINE. $\dot{F}e^2\,\ddot{S}i + 9\,\dot{M}g^2\,\ddot{S}i$ (=Si 41·3, $\dot{M}g$ 47·, $\dot{F}e$ 10).
14. AUGITE or ENSTATITE. $\dot{M}g\,\ddot{S}i$ (=Si 59·71, $\dot{M}g$ 40·29).
15. PIDDINGTONITE, (*Haidinger*). $\dot{R}\,\ddot{S}i + \dot{R}^2\,\ddot{S}i^3$ (=Si 57·66, $\dot{F}e$ 20·65, $\dot{M}g$ 19·, $\dot{C}a$ 1·5).
16. SHEPARDITE, (*Rose*). $\dot{M}g^2\,\ddot{S}i^2$ (=Si 68·91, $\dot{M}g$ 31·02.
17. ANORTHITE. $\dot{R}\,\ddot{A}l\,\ddot{S}i^2$ ($\dot{R}$ being mostly $\dot{C}a$, with a little $\dot{M}g$, $\dot{N}a$ and $\dot{K}$. Taking $\dot{R}$ as wholly $\dot{C}a$, composition would be Si 45·8, $\ddot{A}l$ 25·00 and $\dot{C}a$ 18·09.)
18. LABRADORITE. $\dot{R}\,\ddot{A}l\,\ddot{S}i^2$. ($\dot{R}$ chiefly $\dot{C}a$, $\dot{N}a$ and $\dot{K}$. Composition nearly Si 53·09, $\ddot{A}l$ 30·39, $\dot{C}a$ 16·52.)

* Only those species are enumerated which are supposed to have existed in meteorites anterior to their arrival within our atmosphere.

† I have observed in a single instance among the iron and nickel *matte* of the produce of the dipyrite mine at Gap, Penn., thin lamine of an alloy of Fe and Ni precisely resembling the Tænite of meteoric iron, which consisted of Fe 56·11 and Ni 43·89.

‡ An artificial compound having this composition was produced by Deville.

Amherst College, Sept. 29, 1866.

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ART. V.—*On the Tertiary Formations of Mississippi and Alabama;* by EUG. W. HILGARD, Ph.D., State Geologist of Mississippi.

PORTIONS of the Tertiary formations of Mississippi and Alabama have formed the subject of study of various observers, from time to time, during the past thirty-five years; and the relative age and characteristic fossils of three of the most important divisions, have been determined by the labors of Morton, Conrad, Lea, Lyell, Tuomey and others. Most of these observations, however, have been confined to a few localities, or to such as were situated at short distances from each other in the direction of the strike, though sometimes affording complete sections in that of the dip of the strata.

It is my object in the present paper, to review the general results of my own observations, as combined and collated with those of other scientific observers to whose writings I have been able to refer. If in so doing I am led to controvert the opinions of some, it is in the interest of science, my opportunities for observation having afforded fuller data for reaching correct conclusions. No one can appreciate more than I do, how much American geology owes to the indefatigable research of Conrad, especially. Had he been less active in promoting our systematic knowledge of the Tertiary, I should have had fewer objections to offer to his opinions, and certainly fewer results to science.

Among the sections best adapted to the study of the Alabama Tertiary, are those afforded along the course of the Alabama and Tombigby rivers, by the well-known exposures of Claiborne and St. Stephens, where Sir Charles Lyell first definitively settled the question of the age of the so-called Nummulite, more properly Orbitoides, limestone; and observed the fact, ignored again by some subsequent writers on the subject, that the matrix of Zeuglodon bones always lies below the true Orbitoides limestone.

The Vicksburg and Jackson groups.—In most respects, the Claiborne and the St. Stephens sections agree so closely, that their character was naturally considered as the type of the Southwestern Tertiary, until Conrad's examination of the Vicksburg bluff showed the *Orbitoides* to be there associated with a fauna distinct from, yet equalling in variety and peculiarity, that of the Claiborne sand. In view of the coincidence of leading fossils, nevertheless, Conrad at once considered the part of the Vicksburg profile first examined by him (No. 5 of Sec. 31, p. 141 of my Miss. Report) as the near congener of the Orbitoides limestone of St. Stephens. Yet he seems to have retained doubts as to the precise equivalence of the two divisions, which have lately found expression in the separation attempted by him, of the Vicksburg marl and blue limestone from the Orbitoides limestone proper,

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and the transfer of the latter to the Jackson group. (This Jour., Jan., 1866.)

The collection of shells upon which Conrad based his determination of the latter group (Trans. Acad. Nat. Sci., 1855, p. 257) was unfortunately a selected one.* It led him to the conclusion that the Jackson beds contained no species in common with those of Vicksburg, and a very few with those of Claiborne. Had he been on the spot he would have found, as I did a few years afterwards, that not only do the Jackson beds contain a goodly proportion of recognized Vicksburg fossils, but that the same fauna (though in an indifferent state of preservation) occurs in the marlstone strata overlying the sandy shell-bed, associated with *Zeuglodon* bones, *Laganum Rogersi* and *Scutella Lyelli*. Moreover, the oyster occurring on top of the Jackson beds, as stated in a previous paper is not *O. Georgiana*, but a *Gryphaea* everywhere accompanying the *Zeuglodon;* but also occurring in the Vicksburg marl and limestone. Nowhere in Mississippi has a single Orbitoid been found associated with either the Zeuglodon, or any of the characteristic fossils of the Jackson group. It is quite possible that in Alabama, Zeuglodon bones may have been picked up in company with Orbitoids, equally as well as with drift pebbles. There, the same ravine often cuts into the strata of both groups, and of course commingles their fossils. In Mississippi, I have found this direct superposition only in a single instance; elsewhere, the regions in which the several groups crop out are so far separated geographically, (in consequence of the intercalation of lignitic strata,) as to leave the observer no legitimate chance of error in reference to fossils.

Notwithstanding the defectiveness of his materials, Conrad assigned to the Jackson group its proper place, between that represented by the Claiborne sands and the Orbitoides limestone. He still, however (*l. c.*) thought it most probable that the *Zeuglodon* was referable to the same age as the latter.

A great deal of the obscurity in which the relative age of the Southwestern Tertiary has been involved, is owing to too great a reliance placed by most observers on lithological characters,

* It is impossible to avoid erroneous inferences from the examination of fossils sent for determination by amateurs, and rarely collected with a view to completeness, or general results. From the collection of Jackson fossils submitted to Mr. Conrad, any one would infer that this rich fauna had been totally extinguished by some cataclysm, before the deposition of the Vicksburg strata; whereas in fact, probably more than one-fifth of the former fauna is represented in the latter.

The same has happened with reference to the superior Cretaceous of Mississippi and Alabama, the Ripley group of Conrad, whose fossils as described by him from a *selected* collection forwarded to him, would seem to constitute an isolated group, almost unconnected specifically, with the lower members of the Cretaceous of the Southwest and elsewhere; whereas in reality it shares the leading fossils of the latter, and is connected with the Rotten Limestone group especially, by transitions both lithological and paleontological, as ascertained by myself a year previous. (Miss. Rep., pp. 79, 84.)

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differences as well as resemblances. The "white limestone of Alabama" has so long been quoted as the matrix of the *Zeuglodon* as well as of the *Orbitoides*, that no one seemed to question their being contemporaries. Yet in examining all the records of the occurrence of Zeuglodon bones which I have been able to collect, I have no where found a distinct statement that the Orbitoids have been found associated with them *in situ*. The Orbitoides limestone is mentioned as forming knolls, hill-tops—the *Zeuglodon* as being found in level fields, or in ravines.

The true position of the Zeuglodon bed did not, however, escape the glance of Lyell (On the Nummulite Limestone of Alabama; this Jour. [2], vol. iv); for he distinctly identifies the upper "Rotten limestone" bed of the Claiborne bluff with that which, at Bettis' Hill, contains *Aturea Alabamensis* and *Zeuglodon*, and underlies the Orbitoides rock. The only other observer who seems to have recognized the same fact, is C. S. Hale (this Jour., [2] vol. vi, p. 354). Tuomey, otherwise so accurate in his field observations, ignores it, and speaks only of the "white limestone" in general.

Nowhere has the geologist more need of divesting himself of reliance upon lithological characters, than in the study of the Mississippi Eocene. Not only do the materials of the different groups often bear a most extraordinary resemblance to each other, but their character varies incessantly *in one and the same stratum*, within short distances. Hale (*l. c.*) remarks that in Mississippi, the Orbitoides limestone seems to be represented by blue marlstone, and so it is—sometimes. But while on the one hand we see the hard limestone of the Vicksburg bluff passing into blue marl (Byram, Marshall's quarry), we on the other hand find it passing equally into a rock undistinguishable from that of St. Stephens (Brandon, Wayne county); the varied fossils described by Conrad disappearing almost entirely, to be replaced by millions of Orbitoids imbedded in a semi-indurate mass of carbonate of lime, interspersed at times with similarly constituted conglomeratic masses of *Pecten Poulsoni*.

I cannot therefore, with the lights before me, agree to the propriety of distinguishing as separate divisions the Orbitoides limestone and the Vicksburg group of fossils. Even the occurrence of a different species of Orbitoides (*O. nupera* Con.) at Vicksburg cannot alter the case, for the undoubted *O. Mantelli* occurs there also, in the solid rock. And there are few of the characteristic fossils of the Vicksburg profile, which I have not on some occasions found side by side with the *O. Mantelli* and its companions, the *Pecten Poulsoni* and *Ostrea Vicksburgensis*.

Of course, the coral had its favorite haunts—the mollusks theirs. There is nothing surprising in the fact that where the one abounds the others are usually scarce, or *vice versâ*.

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The Red Bluff group.—In a late paper, above referred to, Conrad proposed to distinguish the lowest fossiliferous stratum ordinarily visible at Vicksburg, and subsequently studied by him (No. 4 of my Vicksburg section, *ut supra*), as a separate group, which he considers as characterized by the occurrence of *Ostrea Georgiana*, and for which he proposes the name of Shell Bluff group. I have elsewhere (this Jour., July, 1866) explained my reasons for dissenting from Conrad as to the position between the Claiborne and Jackson groups, which he assigns to this new division. To the propriety of distinguishing it, however, as a sub-group of the Vicksburg age, I fully agree, though doubting that of giving it the name of a locality from which, as Conrad remarks, but one coincident fossil is known—*O. Georgiana*—while another also occurring there—*O. sellæformis*—in Mississippi and Alabama is confined to the Claiborne group. In a profile of 80 feet, as occurring at Shell Bluff, loose data like those extant regarding this locality, cannot fairly be made a ground of conclusions contrary to the order elsewhere elaborately observed. For aught that is on record, the whole Jackson group may be represented between the beds in which *O. Georgiana* and *O. sellæformis* respectively occur at that place, if (as seems probable from its non-occurrence in the Jackson group of Mississippi and Alabama) the former shell should be so restricted in its range as Conrad supposes.

I believe the white limestone (No. 1 of my Vicksburg section) which underlies the lignite at Vicksburg, but is visible only at extraordinarily low stages of water, to be of the Jackson age, both from its stratigraphical position and the lithological character of the specimens I have seen. But whether it is or not, there can be no reasonable doubt that the usual Jackson strata, which are largely developed on the Yazoo above Vicksburg, underlie at Vicksburg, as well as on Pearl river and Chickasawhay, the Vicksburg group.

The Georgiana bed at Vicksburg is preëminently the habitat of a shell common to the Jackson and Vicksburg stages, but most abundant in the former, viz., *Meretrix Sobrina* Con.; of the two Madrepores described by Conrad, and of *Fulgoraria Mississip.*, all occurring, more or less, in the Vicksburg stage proper. Of the fossil first mentioned, I have after a freshet found hundreds washed out, mingled with numerous masses of Madrepores, sometimes of several pounds weight, with *Fulgoraria*, *Natica? Vicksburgensis*, *Ostrea Georgiana*, etc. The bed has therefore affinities both above and below, and moreover occupies precisely the stratigraphical position of the bed at Red Bluff (Miss. Rept., p. 135). Here the fossils are much more numerous and the affinities in both directions are therefore better expressed. Characteristic and abundant above all, however, is a *Plagiostoma*, which I

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cannot distinguish from figures and descriptions of *P. dumosum*, but hesitate to refer to that species, since it has not been found in the underlying Jackson strata. Lyell mentions the occurrence of *P. dumosum* in the lower portion of the Orbitoides limestone at Bettis' Hill; the same is mentioned by Tuomey, moreover, as occupying a corresponding position in the St. Stephens profile, associated with Orbitoids, and even his description of the lithological character of the bed tallies with that of the Red Bluff deposit. Hale, likewise, mentions *P. dumosum* as one of the prominent fossils of the "white limestone."

The Red Bluff bed seems, therefore, to be more or less coëxtensive with the Vicksburg group, and regularly associated with it as a subordinate feature. Its inconsiderable thickness readily explains its entire absence at many points where, stratigraphically, it ought to appear. Unfortunately, the fossils accompanying *O. Georgiana* at the only locality, other than Vicksburg, where it has been found in Mississippi, have not been observed.

The Claiborne group proper.—That the beds of blue marl and white marlstone, which in my Report I have designated as the "Calcareous Claiborne" group, are strictly equivalent to the typical fossiliferous sand at Claiborne, with underlying limestone bed, is probable both from their stratigraphical position and the correspondence of all the fossils thus far observed; though from the indifferent state of preservation in which the latter are found in the Mississippi stratum, these are few in number. *Ostrea sellæformis* Con. and *O. divaricata* Lea, are the leading shells; I have also recognized *Corbula gibbosa* Lea and *Voluta petrosa* Con. These beds possess fewer good exposures in Mississippi than either of the preceding groups, and may possess many unobserved features. Since publishing my Report, I have received evidence that it extends somewhat farther westward, between the territory of the Jackson and Siliceous Claiborne groups, than it appears on the map. Nor is the division between it and latter groups very well defined, inasmuch as the transition from siliceous to calcareous materials is a gradual one, through strata often very rich in *Scutella Lyelli*, *Pecten Lyelli*, *Ostrea divaricata* and *O. Alabamensis* Tuo.? I am not aware of the existence of any lignite bed in the dark colored clays which immediately underlie the blue marl.

Siliceous Claiborne, or Buhrstone group.—The precise Alabamian equivalents of my "Siliceous Claiborne" group are not nearly so obvious. The extreme variability of its strata both in Mississippi and Alabama (see Tuomey's first Report, and C. S. Hale, *l. c.*), which it seems natural should carry with it a corresponding variation at least in the *predominance* of fossils, and the comparative scarcity and ill preservation of the latter, render its study doubly difficult. I think that, as Tuomey intimates

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(ibid., p. 146) and Conrad more decidedly avers (this Jour., Sept. 1865, p. 266), there is a lower division to be distinguished, which represents the fauna of the Great Lignite epoch, while the upper one seems clearly to be the equivalent of the Buhrstone formation of Georgia and South Carolina. That here as elsewhere in the Mississippi Eocene, lignitic beds should intervene where there is a direct superposition in Alabama, need not surprise us.

Since publishing my Report, I have had some opportunity of examining more closely the southern portion of Newton and Lauderdale counties. I have ascertained that the facies of the white siliceous claystone, so remarkable for its lightness (Miss. Rep., p. 124), is much more extensively developed than I had anticipated; that though often showing lithological transitions into chert and sandstone, it is on the whole characteristic of the superior part of the siliceous division, whose lower portion is represented by the soft yellow sandstone of South Neshoba and North Newton, its lowest probably by the hard, buhrstone-like rock with chalcedonized shells, of the Marion ridge. (Ibid., *l. c.*) All this tallies very closely with Tuomey's observations in Alabama where the "chalk hills" are also a matter of popular remark.

Lower Lignite—Great Lignite group?—The fauna of the lower division, which has never been studied as yet, I conceive to be represented in the small fossiliferous sandstone deposits skirting the Cretaceous in Tippah and Pontotoc (Miss. Rep., pp. 109–112); in the isolated patch of ferruginous green sand of Shongalo, in Carroll, Holmes, Attala and Choctaw counties, Miss., which seems to have been struck again at 415 feet in the bored well at Jackson. (Ibid., pp. 121–123.) As regards this deposit, I will call attention to the fact that it contains *Aturea Alabamensis*, claimed by Conrad as a leading fossil of the Great Lignite, and moreover closely resembles in its lithological characters, the Shark river beds described by Meek and Hayden.

Finally, in Alabama, this era, as Conrad observes, is probably represented in the Bashia creek section of Tuomey's first Report; which, since it is said to contain abundance of well preserved fossils, is well worthy of especial study.

But from this point, Conrad, Hale and others have been led by lithological appearances to extend the limits of the Great Lignite to the southward and westward, to deposits far above it, and even, probably, beyond the limits of the Tertiary.

Conrad (this Jour., Sept., 1865) inclines to refer to this group the buried forest containing tree palms (Miss. Rep., 153), observed jointly by Harper and myself in 1855. The "Nipadites and Cycadites" of that locality, so far as any determination of specimens goes, were "all in the eye" of one of the observers. At all events, the bed lies above the Orbitoides limestone, and with-

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in the Grand Gulf group of my Report; and the "large oyster" overlying marl and limestone, mentioned in the same place, is not *O. Georgiana*, but the *Gryphæa* repeatedly referred to. As for the Vicksburg lignite, it is but one of the many lignitic seams constantly found intercalated between the marine stages of the Mississippi Tertiary. Finally the Port Hudson strata, observed by Carpenter and Lyell, are either the highest of the Grand Gulf group, or form part of the (probably Post-pliocene) formation underlying the Mississippi delta—the "Coast Pliocene" of my Report.

Hale (this Jour., [2], vol. vi, p. 356) goes so far as to identify with the Bashia creek lignite, beds occurring near Natchitoches, and on the Trinity, Colorado and Brazos rivers, in Texas.

I shall not here reiterate the reasons and data given in my Report (p. 109) in support of my opinion that the whole of my "Northern Lignitic" is of the lowest Eocene age, having nothing new to add to what is said there on the subject, and by Dana. (Manual of Geology, p. 510.) In a late letter, Lesquereux informs me that according to the specimens he has examined, there must be a considerable difference of age between the Winston strata marked *c* in my general section (Miss. Rep., p. 108) and those marked *a* in Tippah, and that the former appear to be newer, probably Pliocene. Had the conclusion been the reverse, it might have been more readily reconciled with stratigraphical evidence. Winston county adjoins Neshoba, where, as in Lauderdale, the Lignitic unequivocally dips beneath the siliceous Claiborne strata, and the locality *c* is on the same parallel with the marine outlier of the Claiborne age, in Caroll and Attala. Between locality *c* and the edge of the siliceous Claiborne strata in Neshoba and Lauderdale, the outcrops continue in unbroken succession and uniformity of character; there is nothing to indicate the superimposition of a limited Pliocene basin upon the most ancient Eocene, *here*, any more than between loc. *a* in Tippah and *b* in Lafayette county, which latter Lesquereux is also inclined to consider of later age.

I hope to be able, hereafter, to submit to the experienced hands of Lesquereux more complete sets of specimens from these and other localities situated nearer to the recognized Eocene, with a view to the solution of the interesting problem regarding the correspondence of ancient and modern floras on the two continents.

It is the continuation of these lowest lignite beds of Lauderdale which, in the map accompanying Tuomey's first Alabama Report, is intended to be represented by a narrow band of brown tint, skirting the Cretaceous on the south, across the state. Tuomey was not certain of its eastward limit, and it would appear from the notes of Mr. Thornton, appended to Tuomey's second

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Report, that on the line between the Cretaceous and Tertiary in Barbour county, Ala., no similar strata occur.

Stratigraphical conformation of the Tertiary.—I now turn to the consideration of some of the general stratigraphical phenomena of the Mississippi and Alabama Tertiary, which have given rise to misapprehensions regarding its dip and general arrangement.

I have stated (Miss. Rept., p. 107) that the general dip of the Tertiary strata of Mississippi seems to conform to that of the Cretaceous strata—westward in the northern part of the state, and southward, or nearly so, in the southern. The westward dip of the old Lignitic does not appear to be much greater than the fall of the rivers, from the fact that on the waters of the Tallahatchie and Yallabusha, the same strata appear in the beds of streams for miles, before giving place to higher ones. I do not think the dip can exceed four or five feet per mile; but the variability of materials and small extent of outcrops (which often exhibit local dislocations) render direct observations extremely difficult. As we approach the region of southward dip, however, the inclination becomes more decided and can be observed even in limited outcrops, on streams or railroad cuts trending southward. On Pearl river below Jackson, and on the Chickasawhay, there is no difficulty in recognizing the fact; but yet it is by no means easy to determine correctly the amount of dip, unless by regular leveling operations; the variability of the materials and thickness of the strata, as well as their irregular surface, rendering all the usual pocket instruments unreliable. According to the best observations I have been able to make by reference to the river level, the dip of the Vicksburg strata at Byram (Miss. Rep., p. 145) and of the Jackson strata near Trotter's plantation (ibid., p. 135) amounts to from 10 to 12 feet per mile, S. by W. But this is by no means the maximum or minimum observed, but refers to points where the great regularity of succession for a considerable distance seemed to indicate a normal configuration.

If this estimate be correct (and I do not believe it will hereafter be found to differ materially from the truth), it would go to prove that the upheaval which caused this dip as well as that of the Cretaceous system in Mississippi and Alabama, was a slow one. For the artesian borings on the territory of the former formation, have shown the dip to be about double the above, or 25 feet per mile, in Monroe and Lowndes counties, Miss., and the adjoining portions of Alabama. On the other hand, the strata of the formation overlying the marine Tertiary in south Mississippi possess so slight a dip as, at first, to render its very existence doubtful.

In the general (north and south) section accompanying Tuomey's geological maps of Alabama, the Tertiary strata are rep-

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resented as dipping southward, conformably with those of the Cretaceous. Nevertheless, in the section from Baker's bluff to the lower Salt Works on the Tombigby, he finds the white limestone (= Jackson and Vicksburg groups) occupying "a trough-like depression in the Buhrstone formation." In conversations with me, a few months prior to his death, he expressed his belief that such was the general disposition of the Tertiary strata, and that on close examination it would turn out that the strata passed over in going southward from the border of the Cretaceous, would be again passed over in reversed order, still farther south. My report of the existence in Mississippi, of a lignitiferous formation (the Grand Gulf group) southward of the marine Tertiary, seemed to confirm this view.

My subsequent examination of the Mississippi Tertiary has proved that in Mississippi at least, the disposition is such as first conceived by Tuomey, and laid down on his map; affording a strong presumption that the same is the case in Alabama But at the same time I found, in two different meridians, a similar anomalous reappearance of older strata which had sunk out of view farther northward.

One of these cases is noticed in my Report (p. 128). From Jackson to Canton, a distance of twenty-five miles N. and S., the same clay marl stratum with *Zeuglodon* bones and *Gryphæa* continues on the surface, overlying conformably, as it seems, the lignitic strata, which appear in the bed of Pearl river, just above Jackson, overlaid by the shell-bed. But thence they sink out of view rapidly, and are followed in regular succession by the Jackson and Vicksburg strata. It will be remarked that here there is a singular elbow interrupting the regular E. by S. course of the strike.

The other case occurs on the Chickasawhay, contrary to the statement in my Report (*l. c.*), in making which I overlooked some specimens and notes of 1855, then mislaid.

I find that on the very southern edge of the Vicksburg territory in Wayne county, at Dr. E. A. Miller's (p. 146), I collected *Gastridum vetustum*, *Morio Petersoni*, *Laganum Rogersi* and other Jackson fossils, from a blue sandy marl directly underlying the St. Stephens limestone teeming with Orbitoids. North of this locality, the Vicksburg strata alone are seen outcropping until we reach Red Bluff, where the Jackson strata disappear beneath those of the Red Bluff group. Within this distance of about ten miles, not only have the Jackson strata "dipped up" again, but the Red Bluff group, with its concomitant green clays and stiff clay marls (nearly a 100 feet in thickness altogether) has vanished from between them and the Vicksburg strata proper. It might therefore be suspected that the whole formation was here thinning out, and that we were near the edge of a basin.

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So far, I have been unable to observe the marine Tertiary in juxtaposition with the Grand Gulf group on the Chickasawhay, and cannot positively assert that the former dips under the latter at all. In Hinds, Rankin and Smith counties, their relative age is clearly exhibited, but it is possible that they do not overlap very far, so that, were a portion of the superior formation removed by denudatiou, the edge of the marine basin might be laid bare. Yet from the fact that at the very locality mentioned, the Vicksburg strata proper possess approximately the same aggregate thickness as elsewhere observed, we should not conclude that the stratum is about to run out. Nor is it easy to reconcile such a supposition with the grand scale on which these marine strata are developed in the direction of their strike, through the states of Alabama, Mississippi and Arkansas, and their relations to the Great Lignite. It would seem more natural to suppose that they form part of the deposits of a tertiary Gulf of Mexico, and now (either themselves or their deep sea equivalents) underlie that gulf. Under this point of view, they might possibly be expected to reappear in Yucatan, along the foot of the Mexican plateau, in Texas, and forming a tongue, as it were, in the direction of the long cretaceous Mediterranean, and tertiary fresh-water sea which is marked by the Great Lignite of the upper Missouri.

In view of the slight dip of the Mississippi Tertiary, the anomalies mentioned may find their explanation in undulations of the sea-bottom upon which these strata were deposited. A dip of ten feet per mile does not differ very sensibly from the horizontal, and a stratum deposited on such a slope would not necessarily, on that account, vary much in thickness. If at the time of the deposition of the Jackson group, a northward slope to that extent existed between Jackson and Canton, a subsequent general upheaval to the northward would render that slope a horizontal plain, while the strata heretofore horizontal would acquire a southward dip to the same extent. Similarly, if between Baker's bluff and the Salt Works on the Tombigby, or between Dr. Miller's and Red Bluff on the Chickasawhay, the sea bottom had a slight trough-shaped undulation (such as the ocean beds of our time frequently exhibit), the existing state of things would result. Artesian borings lower down on the Tombigby river may hereafter inform us whether or not the white limestone underlies there, as by analogy with the Pearl river beds it might be expected.

While, however, the general features and position of the Tertiary as well as of the Cretaceous strata of Alabama correspond closely with those observed in Mississippi, it seems, contrary to what one would expect, that the absolute amount of southward dip is somewhat less in the former state. No numerical data re-

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garding this point are given, but from the great breadth of country upon which outcrops of one and the same group of the Tertiary occur in Alabama, the fact is apparent enough as concerns the latter. Whether the same is true of any part of the Cretaceous, is doubtful; unless the great north and south width of the Ripley group, as exhibited on Chunnenugga ridge in Macon and Barbour counties (according to Tuomey's and Thornton's observations combined), should thus find its explanation. It seems doubtful, in fact, whether the true Rotten Limestone (if it exist there) comes to the surface at all. This is the more remarkable from the near proximity of the primary and metamorphic rocks of that portion of the state, whose original upthrusting would thus be proved to ante-date greatly the general Allegheny upheaval.

The Grand Gulf group.—I have considered the older and well-defined eocene Tertiary apart from the two other groups described in my Report, whose age is doubtful and whose relation to the former is not well recognized. A glance at the map nevertheless shows that so far as extent is concerned, the Grand Gulf group is perhaps the most important of the formations of the state of Mississippi, and that, judging by the trend of its outlines on the Mississippi river, it must be still more so in Louisiana; while in Alabama it rapidly contracts, and attracts so little attention that I find but two observers who, *passim*, advert to anything resembling this formation as it exists in Mississippi.

Conrad (this Jour., [2], vol. ii, 210) states that the bluffs of Vicksburg, Grand Gulf, Rodney and Natchez, have a similar geological origin; that their lower portion is of marine origin, and a member of the Eocene.

I am unable to refer to a prior publication, mentioned by Conrad, for the data upon which this determination is based, so far as the bluffs below Vicksburg are concerned. I have made detailed examinations of the profiles at Grand Gulf and at Fort Adams, at the extreme limits of the formation in Mississippi, and I may say, of all the important outcrops in the interior; but thus far, have failed to find even a trace of a marine fossil, and in fact, but a single specimen—a bone fragment as I take it—likely to prove of zoogene origin. Vestiges of vegetation are common, but only in one instance, so far, have I found any specimens likely to admit of exact determination. I refer to the deposit on the Chickasawhay, already referred to, which exhibits the trunks, stumps and roots of an ancient forest, inhabited, among other trees, by tree palms. But even here, scarcely anything beyond the most general outlines of a few leaves can be traced. It may be that in proximity to the (rare) lignite beds of this formation, better success might be had—as has been the case in the Lower Lignitic. In the sand- and claystones belonging

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to this group, neither Wailes, who resided amongst them and gave the name of "Davion rock" to one variety of the former; nor myself who have delved in scores of exposures, have ever found a trace of any fossil whatsoever.

The Natchez bluff I have not visited; but Wailes, who resided within six miles of it, must have done so, and he is silent on the subject of any but the Loess fossils, although he mentions all other fossiliferous rocks occurring in the State. Thus, while I have seen mentioned in various places "marine strata at the foot of Natchez bluff," I cannot trace the report to any authentic source. I shall endeavor to settle the point as soon as possible, but meanwhile observe, that according to reliable information given me, the Rodney bluff is essentially a counterpart of that at Grand Gulf; a detailed profile of which, obtained at a medium stage of the river, is given in my Report (p. 148).

The extreme scarcity of fossils in this formation is the more remarkable, as from the regularity of its stratification it is manifest that it has been formed in quiet water, and it contains a great variety of materials suitable for the preservation of either fauna or flora. Even the strata containing carbonate of lime, however, seem to have had nothing to fossilize, save in the solitary instance of a doubtful fragment of cellular bone already mentioned. In some portions of it, we might imagine that the abundance of soluble salts (which pervade more or less the entire deposit) indicated the former existence of bitter lakes, incapable of harboring life; but this could by no means apply to the formation as a whole.

The only probable presumption in favor of referring it to the Eocene, so far as I know, arises from the lithological resemblance and transition of its strata, at its northern limit, to those of the Vicksburg group. The upper division of the latter group in the neighborhood of Brandon is undistinguishable from the materials of the Grand Gulf group at many points, and I so referred them until I found them overlaid by a string of limestone nodules containing *Orbitoides*, about forty-five feet above the uppermost sands of the Vicksburg group. (See section, Miss. Rep., p. 140.) At a level about forty feet higher, the characteristic soft white sandstone of the Grand Gulf group crops out.

This, however, amounts to mere conjecture; and, *per contra*, toward the sea-coast the lithological transition into the materials of the "Coast pliocene" seems about equally cogent. The mere fact that tree palms are found in the formation, amounts to nothing, inasmuch as these grow at the present time in the same latitude in South Carolina.

The existence of this formation in Alabama appears from Mr. Thornton's notes (2d Rep. Ala., Appendix), in which he mentions similar materials as overlying the (Vicksburg) marine Ter-

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tiary at its southern limits. Moreover, Bigelow (this Jour., ii, 419) describes a sandstone formation in Baldwin county, Ala., which impresses me as though it might be Grand Gulf sandstone overlaid by the ferruginous sandstone with tubes, of the Orange Sand group (Miss. Rep., p. 9), "filled with variously colored sand." Bigelow states that in the lowest portion of this rock he has seen obscure impressions of shells; which, if my conjecture be correct, might offer an opportunity of determining the age of the group. The same rock is said to occur at Pensacola.

The "blue clay bottom" of the Coast—"Coast Pleiocene."—Finally, as regards the imperfectly known black clay formation of the coast (Miss. Rep., p. 154, ff.), a comparison of specimens of shells and borings obtained from the New Orleans artesian well,* in 1854, seems to show that it underlies the whole of the delta, perhaps as high up as Port Hudson, whose subterranean Cypress swamps, observed by Carpenter and by Lyell, may belong to this formation. No Eocene fossils have been brought up by the augur, even from the lowest shell-bed found, at the depth of 570 feet, (the greatest depth was 630); while from among the shells of the first bed struck, at 41 feet, I have thus far determined eighteen marine species, all now living in the Gulf. At 153 feet a trunk of cypress, with bark, was found. At 256 feet, some extinct, or if living, undescribed shells seem to occur; and at 480 a Gnathodon bed. I hope to be able to determine by microscopic comparison whether or not the Grand Gulf group has been passed through or reached in this bore, which from present appearances has penetrated both Post-pleiocene and Pleiocene marine deposits. This would parallelize more closely the Tertiary of the Atlantic coast and of the Gulf; though so far as I know, nothing apparently corresponding to the Grand Gulf era has been observed in the former series. Should the chain of the Antilles, after the close of the Eocene epoch have for some time cut off the Gulf of Mexico from the Atlantic, it seems possible that the deposits of the former might have changed their character to the extent required by the facts observed. A strong influx of fresh water—perhaps that pertaining to the Great Lignite era—from the continent might for the time being have extinguished the Eocene marine fauna without replacing it by another sufficiently numerous to be readily detected in the deposits of the period, which might thus correspond to the Atlantic Miocene. Upon the subsequent irruption of the Gulf stream through the Antilles chain, the formation of normal marine deposits along the margin of the Gulf would be resumed.

University of Mississippi, July 26, 1866.

* These specimens were furnished by Drs. Copes and S. S. Riddell, of New Orleans, to Maj. Gen. A. A. Humphreys, and by him referred to me for examination; which, however, is not yet completed.

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Art. VI.—*Evidences of the existence of ancient Local Glaciers in the White Mountain Valleys;* by A. S. PACKARD, Jr., M.D.

THE following observations were made during the past autumn in the valleys of the tributaries of the Saco, and Androscoggin rivers. At Jackson, N. H., on Thorn mountain, which lies just south of Tin mountain, there are some well marked glacial scratches which point directly toward Mt. Washington, which stands at the head of the valley of the Ellis river; their course being N. 25° W. These were first noticed on quartz veins running over the ledges which have been polished smooth as porcelain and finely grooved. At other places on the same mountain part way up, and also upon the summit, upon removing the soil, similar striæ occurred running in the same direction. On this mountain and the neighboring hills occurred occasional boulders of a peculiar mica slate, enclosing crystals of staurotide, which had evidently been transported from near the summit of Mount Washington. The summit of Mt. Kearsage we found moulded by ice. Dr. C. T. Jackson in his report on the Geology of New Hampshire states that the drift scratches one half way up Mount Kearsage run N. 30° W. He also states that on Mount Chicorua they run N. 35° W. (S. 35° E.), which is the course of the Ossipee valley just below it.

On a hill just east of Goodrich's falls on the Ellis river are very distinct ice-marks, on polished surfaces, with striæ running N. 30° W., and lunoid furrows with their horns pointing up the valley in the same general direction as the grooves.

Crossing over the mountains into Chatham, and Stowe, Maine, into the valley of the Cold river, another tributary of the Saco, we find another set of striæ. The broad summit of Speckled mountain, opposite Mt. Royce, which two mountains guard the southern entrance of Evans' Notch, is glaciated both on the N.W. and N.E. flanks. Here also is a "col," down which the ice must have moved in both directions. Near the summit the grooves and lunoid furrows run N. 15° E., following the course of the valley at this place, and aiming at a higher peak to the north and east. On Mt. Baldface, 3600 feet high, three or four miles southward, the grooves are very clearly indicated both below and directly upon the summit. Here they run N. 10° W., and it might be mentioned that the Cold river valley turns more to the southeast at this point. On a shoulder of the mountain, perhaps 300 feet below the summit, the lunoid furrows are especially abundant.

On the summit of this mountain, which is made up of a light colored fine syenite, were a few boulders of a peculiar porphyritic syenite, with oblong crystals of albite. Following the N. 10° W. course, less than a quarter of a mile, we traced them to the

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parent rock composing Peaked mountain, which is somewhat lower than Baldface, at least 100 feet.

Again, crossing the high range of mountains over into Gilead in the Androscoggin valley, glacial marks directed N.W. occurred on a high ledge near the river, indicating that the ice moved from the northwest, pursuing the general course of the valley at this point.

Here, then, are good proofs of distinct systems of glaciers radiating from a central *mer de glace* which capped the White mountains. This dome of ice must, so far as our slight observations show, have been soon subdivided into local glaciers which pursued their route down the different valleys to the sea. Thus following down the Androscoggin river, at Lewiston, the ice-marks run nearly north and south, the course of the valley at that place, as we are informed by Mr. G. J. Varney of that town; and at Brunswick, on the seashore, there are deep furrows running in a N.W. direction, being the ancient course of the river where it undoubtedly entered the sea, up to a late period of the Terrace epoch.

ART. VII.—*Experiments on the Electro-motive Force and the Resistance of a Galvanic Circuit;* by HERMANN HAUG.

[Concluded from vol. xlii, p. 389.]

NATURALLY I first inquired whether or not the experiments of other observers would exhibit peculiarities of a similar character. I am not fortunate enough now to have a great choice of material at hand. But the experiments of J. Müller, cited on page 384, with six cells of Daniell's, if every possible combination of two different intensities is calculated, show decidedly a similar great increase of the internal resistance with the decrease of the combined intensities, viz:

For cell	No.	1,	from	2·85	to	5·19
"	"	2	"	3·41	"	4·76
"	"	3	"	3·02	"	4·07
"	"	4	"	3·19	"	4·07
"	"	5	"	3·08	"	4·73
"	"	6	"	3·68	"	4·19

As I have every reason to believe that in these experiments the circuit was really opened every time a greater resistance was to be introduced, I considered this circumstance, or the reverse, as not of any great account, and tried to determine at least the general character of its influence upon the results of all the other circumstances which may be regarded as important.

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With this object in view, I preferred to exchange the nitric acid for a properly acidulated solution of bichromate of potash, since a battery with this liquid, after having been used for some time, possesses much less reliability as regards constancy than the Bunsen battery. The results of this series of experiments are recorded in table VI. They are very irregular, from errors of observation, and from what are called the fluctuations of the electro-motive force. For every external resistance two mean values of the internal resistance are calculated, one from the first half, the other from the second half of the single observations. These mean values are:

For centim. of platinum in the circuit.	First mean value.	Second mean value.	For centim. of platinum in the circuit.	First mean value.	Second mean value.
2	25·69	25·00	30	37·33	34·37
4	36·5	28·42	40	34·72	36·09
6	33·34	31·08	60	41·37	39·76
8	33·44	31·69	120	41·85	39·57
10	31·36	31·75	200	41·54	40·09
20	35·27	34·66			

In nine out of eleven cases the mean values of the first observations are greater than the mean values of the last observations. From this fact I thought myself warranted to believe that all those circumstances together which may be considered as influential upon the results, generally tend to diminish the ratio of increase, or at least, that in my experiments they would not increase this ratio. I therefore considered the results of my experiments reliable enough, as far as the fact of the great increase of internal resistance was concerned, and I changed only the manner of determining the intensity by observing the deflections of the swinging needle, both ways, and taking the mean, instead of waiting for the resting of the needle. In this way I made two series of observations, the results of which are given in tables VII and VIII. The battery was Bunsen's, the acids having been used once before.

Since the heating of the thin platinum wire of the reochord prevented me from observing higher intensities (those above tan. = 0·6), and calculating upon them, and since I was aware that the influence of temperature upon the resistance of conductors would probably be, and has been, considered as sufficient to explain the increase of internal resistance, as proceeding from the common method of calculation, I prepared myself a rather imperfect reochord with copper wire, because this metal becomes heated but very little, and would afford me to compare the results of very different intensities. Table VII contains the results of experiments with this copper wire rheochord. All resistances are expressed in centimeters of this copper wire. Experiments of table VIII are made with the platinum wire rheo-

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chord, besides which the circuit constantly contained 200 centimeters of thin copper wire. As to the calculation of the internal resistance I have to make the following statements.

The vertical columns (*a*) of both tables exhibit this resistance when calculated after the common rule, viz: combining the direct intensity with every lower intensity.

In table VII, the column (*a*) gives an increase of internal resistance, if only the mean values of the first, and last, five observations are taken, from 103·95 to 128·51, or from 1 to 1·24. In table VIII, the corresponding column (*a*) gives, from the first and last, three values, an increase from 6·5 to 10·55, or from 1 to 1·61. For the whole range of intensities, between the limits 1·982 and 0·7844, the increase of resistance therefore is as 1 to 1·24×1·61, or as 1 to 1·996. The two centimeters of platinum wire were far from being red hot, yet it is difficult to decide, whether or not, this increase can be explained simply by the influence of temperature, the latter not being determined. I thus failed to get a direct proof that the increase of internal resistance, as visible after this way of calculation, is decidedly greater than the temperature of the measuring wire could account for.

But thinking the matter over I found why this way of calculation is wrong. The first direct observation belongs to a circuit, with high intensity, and where there is no part of it heated considerably. With this observation there are to be combined, first, the observation of an intensity somewhat lower, but the measuring part of the circuit heated very much; second, the observation of a low intensity within a circuit heated but very little. It seems evident both as regards the influence of temperature, and as regards the supposed influence of the intensity of the current, upon the internal resistance, that in this way matters become rather mixed up, and mean results are arrived at, instead of the extreme values sought after. To study the influence of temperature, of intensity of the current, upon the internal resistance, requires therefore to combine with each other, first, two observations of high intensities in circuits, with the measuring unit of resistance heated considerably; and second, two observations of low intensities at which this unit of resistance is heated but very little. Estimating then the ratio of increase, due to the difference of temperature of the unit of resistance, the quotient of it into the actual ratio of increase will give the ratio of increase of the internal resistance, due to the difference of intensity of the current. Of course, it would be much better to provide means for keeping the unit of resistance at constant temperature, but I refer to the method of determining the constants of the battery as commonly practiced.

In order to eliminate as much as possible, the errors of obser-

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vation I preferred to calculate upon the combination of every two intensities. The results are contained in the vertical columns to the right of columns (*a*), of tables VII and VIII. In table VII, I further calculated the mean of the last five values of each vertical column from (*a*) to (*b*); and the mean value of all the other figures. The table shows unmistakably a general and great increase of the internal resistance with decrease of observed intensities. Comparing now the mean of the first five values of column (*a*), not with the mean of column (*b*) which may be too high, but with the mean of all the last figures, which is still less than the mean of 171·6 and 198·9; we get a ratio of increase of from 103·91 to 183·6; or 1 to 1·77; and this for a reduction of intensity from 1·982 to ·7844, or from 2·53 to 1; and for a reduction of temperature of the unit of copper wire which I should not think at all sufficient to explain that ratio.

In table VIII, calculated in the same way, the mean values at the foot of it embrace only the last three figures of each column. Comparing here the mean of the first three figures of column (*a*) with the mean of the last two mean values, viz: $\frac{15{\cdot}81+18{\cdot}35}{2}=17{\cdot}08$, in order to avoid any overrating, we get an increase of from 6·5 to 17·08, or from 1 to 2·63, which again cannot be accounted for solely by the difference of temperature of the unit of resistance. This ratio is therefore partly due to the ratio of decrease of intensity of the current which amounts to $\frac{{\cdot}7844}{{\cdot}091}$, equal 8·62 to 1.

In table VII, with the copper wire rheochord, a reduction of intensity to $\frac{1}{2{\cdot}53}$, and of temperature of the rheochord wire to an unknown extent, are attended with an increase of internal resistance from 1 to 1·77. In table VIII, with the platinum wire rheochord, a reduction of intensity to $\frac{1}{8{\cdot}62}$, and of temperature of the rheochord wire to an extent much greater, I have no doubt, than in case of the copper wire, is followed by an increase of internal resistance not more than from 1 to 2·63, being less, in proportion, than in case of table VII. It therefore seems that the increase of internal resistance, as proceeding from difference of intensities, is greater at high intensities than at low intensities of the current. And combining now the results of both tables, we find an increase of internal resistance from 1 to $1{\cdot}77\times 2{\cdot}63$, or from 1 to 4·655, this increase being due first to the reduction of intensity from 1·982 to ·091, and second to the difference of temperature of the unit of resistance, which however could not produce half that ratio, I should think.

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In computing these figures I made use of the values of columns (*a*), after having raised objections against them. But it seems to me that I thereby did not unduly increase the results, attributing them as I do to the full difference of intensities, and to the difference of temperature as proceeding from the second intensity and the lowest. Considering this circumstance as chiefly affecting the results of columns (*a*), it appears also evident that the increase of resistance within this column is not so much the result of difference of temperature, as of difference of intensity, since the influence of intensity starts from 1·982 in table VII, and 0·7844 in table VIII, while the influence of temperature starts in correspondence with intensity 1·8008 in table VII, and 0·6063 in table VIII.

There is another circumstance connected with table VIII, the experiments having been made with a circuit containing constantly 200 centimeters of thin copper wire, as an addition to the internal resistance. If the resistance of this copper wire, and the true internal resistance are calculated separately, by means of combining the two first intensities with each of the following ones, there result values contained in columns (Cu) and (R). Both of them show the same ratio of increase as column (*a*), confirming the fact as exhibited in table V. Thus far, the addition of the 200 centimeters of copper wire to the internal resistance proper, does not seem to modify the ratio of increase.

The experiments for tables VII and VIII, still were rather unsatisfactory, showing too great irregularities. To avoid them, if possible, and with a view to get a clue to the understanding of the matter, I undertook another series of experiments, with as much care as I could afford, and the instruments at my command would allow. I made four pairs of observations, two for each end of the swinging needle alternately, and took the mean value of them. The battery was a Bunsen's; the diluted sulphuric acid containing rather much sulphate of zinc, and the nitric acid having been used for a short time. Using such acids my object was plainly to get results about facts of ordinary occurrence. I tried the battery first without any unnecessary addition of other resistances than the platinum rheochord, and afterwards with an addition of 25, 50, 100, 150, 200 centimeters of thin copper wire. The results of these observations, calculated in the same way as explained for tables VII and VIII, are recorded in tables IX to XIV. I did not succeed, the results remaining irregular, probably partly from constant faults of the instruments, and of the location of the tangent compass within about 15 feet distance from an iron stove, and within about five feet distance from about five pounds of iron which could not be removed. I therefore had to content myself with these results, and to use them with caution.

In table IX, the mean of the first three values of column (*a*)

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is 3·21; the mean of the last three values of the same column is 6·34. The increase is in the ratio of 1 to 1·975. Leaving out the value of column (*b*), as too low, but taking the mean of the six mean values to the left of column (*b*), from 17·31 to 23·03 there being three small and three large values, we get an increase of internal resistance from 3·21 to 18·51, or from 1 to 5·77. This increase is due to the reduction of intensity from 1·3422 to 0·0581, and to the reduction of temperature of the unit of resistance, from dark red heat of the 6 cm. of platinum wire, to about the temperature of the air.

It may be well to examine with some detail this series of observations. The battery was in such a state that the direct intensity decreased rapidly during the short time necessary for 4 pairs of observations of the needle. The intensity with any length of platinum wire in the circuit, was variable too, becoming diminished with short length, and increased with great length of the wire. The examination of the following figures will give an idea of the amount of this variation of intensity. They are the mean values for the first, respectively for the second two pairs of observations:

Cent. of plat. wire in the circuit.	Intensities.		Cent. of plat. wire in the circuit.	Intensities.	
	First.	Later.		First.	Later.
0	1·5039	1·3605	50	·1437	·1441
6	·4679	·4665	60	·1267	·1259
8	·4119	·4097	70	·1118	·1130
10	·3721	·3729	80	·1000	·1016
12	·3402	·3424	90	·0898	·0919
14	·3177	·3153	100	·0814	·0840
16	·2929	·2934	110	·0748	·0774
18	·2762	·2783	120	·0705	·0726
20	·2594	·2596	130	·0652	·0677
30	·2052	·2048	140	·0608	·0634
40	·1674	·1700	150	·0567	·0585

Owing to this change of intensity, it would be necessary to calculate upon the first observations rather than upon any later ones, or upon some mean values. If I do so, I get in column (*a*), 3·01 and 5·89 as mean values, with an increase from 1 to 1·957; instead of the above values 3·21 and 6·34, with an increase from 1 to 1·975. The true ratio of increase is therefore somewhat less than calculated from the table, and this holds good for the whole ratio of increase.

On the other hand, if the decrease of intensity with the time, is mainly to be assigned, as probably will be maintained, to some polarization having taken place, which, from the high direct intensity to the next with 6 cm. of platinum wire in the circuit, will be kept for some time near its maximum; then the intensity with 6 cm. of rheochord wire is lower than it would be, had the circuit not been closed, directly and constantly, previous to the observation with 6 cm. of platinum wire, since this low

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intensity cannot possibly produce the maximum of polarization. Assuming therefore the intensities with 6, 8 and 10 cm. of platinum wire too low, the mean value in column (*a*) would become yet smaller than 3·01, and the ratio of increase of resistance therefore greater than 1·957, if not greater than 1·975. And this again holds good for the whole ratio of increase.

Considering all these circumstances, I think that my discussion of the combined results, from table VI, is not much at variance with the truth, and that my figures do not exaggerate the facts in any high degree.

There is an other point to be considered. The decrease of intensity with 6, 8 and 10 cm. of rheochord wire in the circuit amounts to a mean of 0·0013. When the circuit is closed directly, this decrease of intensity, for about the same time, amounts to 0·1434, that is, to many times more than the difference of intensities amounts to. The intensity 1·5039 within the circuit closed directly, is the mean value of two pairs of observations, one for each end of the needle, being respectively 1·5845 and 1·4233, with a decrease of 0·1612. This rapid decrease of intensity would justify starting the calculation of column (*a*) from the direct intensity 1·5845 instead of from any later intensity, or from any mean value. If I do so, and compare this intensity with the first intensities given above, the mean values for the first and for the last three figures of column (*a*) become 2·80, respectively 5·58, the ratio of increase being 1·993 against 1·975 from the table. And the whole ratio of increase of resistance would become $\frac{3\cdot21}{2\cdot80}=1\cdot1465$ times greater than was resulting from the table. This increase, due to the greater direct intensity started from, exemplifies however the intensive degree of influence of the intensity of the current upon the internal resistance, as compared with the influence of the temperature of the unit of resistance.

I suppose, after all, that one may possibly consider the great ratio of increase of internal resistance as figured from table IX, to be the consequence, to a great extent of polarization to which any inconstancy of a battery is usually assigned, and the battery was in fact rather inconstant. But apart from my above reasoning to the contrary, I can refer to table I, the experiments for this table having been made with a battery the acids of which had been used for but a very short time. The degree of constancy of this battery may be judged from the fact that the compass needle was at 60·8° at the beginning of the experiments and at 60·2° one hour later, during which time the battery had been in use, except for very few minutes. Now, if I combine the intensities for several great resistances in the circuit, and take the mean of three consecutive values, I get 15·65, 19·46,

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24·97, 17·92, as internal resistances. The mean value of all of them is 19·5, and the internal resistance as calculated from the direct intensity, and that with 8 cm. of platinum wire in the circuit, being 3·48, there results an increase from 1 to 5·604, without the platinum being red hot, against 5·77 of table IX, with the platinum wire red hot indeed. At any rate the polarization cannot play a great part in the results of my experiments.

Comparing the results of tables IX to XIV, I get from the mean values the following

Table of ratio of increase of Internal Resistance, with constant addition of different lengths of copper wire in the circuit.

Length of copper wire in the circuit.	Resistances of columns (*a*)		Ratio of increase.	Mean highest resistances.	Total ratio of increase.
	Lowest.	Higher.			
0	3·21	6·34	1·975	18·51	5·77
25 cm.	3·88	7·77	2·003*	20·17	5·20
50 "	4·33	8·49	1·961	20·67	4·77
100 "	5·02	9·79	1·95	21·30	4·24
150 "	6·61	11·66	1·764	22·24	3·36
200 "	7·65	12·94	1·691	23·44	3·06

The table illustrates the dependence of the ratio of increase on the manner the directly closed circuit is built up, on the greater or less intimacy of the contact, etc.

In tables X to XIV, column (Cu) contains the resistances of the respective lengths of copper wire. The increase of resistance maintains the same ratio as in the respective columns (*a*). Using mean values, I derive, from comparing all five tables, the following results.

Length of copper wire.	Resistance at high intensity.	Respective resistance of 25 cm. length.	Resistance at low intensity.	Respective resistance of 25 cm length.
25 cm.	·50	·50	·993	·993
50 "	·85	·425	1·666	·833
100 "	1·66	·415	3·237	·809
150 "	2·76	·46	4·877	·813
200 "	3·62	·452	6·12	·765

The resistance of 25 cm. of copper wire, expressed in centimeters of platinum wire, at high intensity, is rather irregular, the first value in particular being too great. It is, however, in agreement with all other facts, safe to say that the resistance of a given length of copper wire, or the specific resistance, appears the greater the longer the measured wire is. This is contrary to what may be expected from the different influence of temperature upon the resistances of copper and platinum, exemplifying again the supposition that there is some other reason for the increase of resistance in columns (*a*), overruling the influence of difference of temperature. At low intensities, the specific re-

* The observation with 25 cm. of copper and 4 cm. of platinum wire in the circuit, gives a ratio of increase comparatively too great, on account of this length of platinum wire having been hotter than in any other case.

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sistance of the copper is actually decreasing with the length of the measured wire, and this seems to indicate that at low intensities, the influence of temperature upon the resistance of conductors prevails over any other reason which, in a galvanic battery, and with this method of determination and calculation, may modify the resistances, actually or apparently.

It was desirable to determine the resistance of the copper wire at low intensities, without any interference on the part of high intensities. The last observation of each of the tables XII to XIV, each with 100 cm. of platinum but with no copper wire in the circuit, enabled me to do so. From

$$I_1=\frac{E}{W+C+P_1};\ I_2=\frac{E}{W+C+P_2}\ \text{and}\ I_3=\frac{E}{W+P_3},\ \text{there follows}$$

$$C=\frac{P_3I_3(I_1-I_2)-P_2I_2(I_1-I_3)+P_1I_1(I_2-I_3)}{I_3(I_1-I_2)}.$$

Putting $I_1=0{\cdot}1900$, $P_1=30$; $I_3=0{\cdot}0832$, $P_3=100$, and afterwards
" $=0{\cdot}1580$, " $=40$; " = " " = " all from table XII, and combining them successively with each of the observations with from 50 to 100 cm. of platinum, and 100 cm. of copper wire in the circuit, as per table XII; and further calculating, after the same manner, with the corresponding figures of tables XIII and XIV, there result, as the mean values from 12 single ones, the following resistances:

Length of copper wire.	Resistance.	Resistance of 25 cm. length.
100	4·465	1·116
150	5·128	0·855
200	5·125	0·641

It becomes here more evident that at low intensities the specific resistance of the copper wire appears to increase with the intensity, respectively with the temperature produced by it.

Of course the above figures cannot be compared with those given on page 50, since the latter values were derived from the highest direct intensity. In order to connect the results of both calculations, I combined first, the intensities 0·8865 and 0·0832, and afterwards the intensities 0·373 and 0·0832, with each of the six observations before the last, all of table XII. The values resulting therefrom, in columns 1 and 2 of the following table, com-

1.	2.	3.	4.
12·3	7·74	4·84	3·53
9·74	6·62	4·73	4·19
7·13	5·02	3·66	3·25
6·35	5·81	5·27	5·19
5·08	4·73	4·53	4·49
4·49	4·78	4·93	4·95
	Mean,	4·66	4·27

pared with those in columns 3 and 4, which the above mean value (4·465) is derived from, go again to show a general de-

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crease of resistance of the copper wire with decrease of observed intensities, the last horizontal row of figures making the only exception, if one and the same low intensity is considered. The values in columns 3 and 4, do not decrease, on account of errors of observations, I suppose. If calculated for table XIII, column 3 is decreasing, column 4 increasing. If calculated for table XIV, both columns 3 and 4 are decreasing, from the mean of the first three values to the mean of the last three.

It seems to me that the facts here illustrated, give a new reason for the great difference of the specific resistances of conductors, as derived by different observers from experiments, under conditions much varying and either partly unknown, or at least underrated in their influence. From observations of Davy, Becquerel, Ohm, Christie, Lenz, Pouillet, Buff, Frick, Müller, Lamy, Arndtsen, Matthiessen and Wiedemann, as recorded in G. Wiedemann's Galvanism, 1863, I extract the following table of the extreme values of the conducting power of different metals, for which the conducting power of silver is taken as 100. The values vary

For copper	between	the	limits	65·8	and	280·9,	ratio	1	to	4·27
" gold	"	"	"	55·2	"	161·8,	"	1	"	2·93
" zinc	"	"	"	24·06	"	93·6,	"	1	"	3·88
" tin	"	"	"	11·45	"	47·2,	"	1	"	4·12
" iron	"	"	"	12·35	"	48·9,	"	1	"	3·96
" platinum	"	"	"	7·93	"	48·0,	"	1	"	6·05
" lead	"	"	"	7·77	"	63·3,	"	1	"	8·15
" antimony	"	"	"	4·29	"	6·5,	"	1	"	1·51
" mercury	"	"	"	1·63	"	4·62,	"	1	"	2·83
" bismuth	"	"	"	1·19	"	1·9,	"	1	"	1·6

While the method of calculation of columns (Cu), (R) and (a), of tables X to XIV, gave the appearance of the ratio of increase being equal for the whole amount, and every part, of the so-called internal resistance, the copper wire included, the above computations show that, for low intensities, the copper wire follows its own rate of increase, or rather decrease, leaving indeed, as was to be expected, the full amount of increase with the true internal resistance, viz., within the liquids of the battery. In table XII, the mean of the first three values of the true internal resistance, in column (R), is 3·66. The same true internal resistance at low intensities, may be calculated either by the formula

$$(R)=\frac{(P_2-P_1)I_1I_2-P_2I_2(I_1-I_2)}{I_2(I_1-I_2)},$$

with the same observations, (Cu) has been calculated, as per page 51; or, the values for (Cu) computed there, and specified in columns 3 and 4, on page 51, may simply be deducted from the corresponding mean values of the whole internal resistance of table

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XII. Thus we get (R) at low intensities, equal 20·90−4·66= 16·24; and equal 21·99−4·27=17·72; with a mean of 16·98. From 3·66 to 16·98, the increase is as 1 to 4·64; while the increase of the full internal resistance, the copper wire included, is only from 5·02 to 21·445, or from 1 to 4·27, for the corresponding values of table XII. Here again the influence of the introduction of 100 cm. of copper wire appears as reducing the true amount of increase of resistance, and it seems safe to recognize this increase as residing mainly if not entirely, within the liquids. The contrary result exhibited in columns (Cu), (R) and (*a*), is therefore due exclusively to the method of calculation.

My series of experiments, most of them, show the values for the internal resistance, after the general great increase, to decrease for the lowest intensities. This becomes more visible from a graphical representation of the course of the internal resistance. This circumstance may partly depend on constant faults of the observations of small deflections of the compass needle. But it seems certainly to depend partly on the circuit being formed with copper conductors. The influence of the intensity upon the internal resistance, appears to become constant at low intensities. Any further variation of the internal resistance will then be due to the influence of temperature upon the liquids on one side, and upon the copper conductors on the other side. Now, as the resistance of the copper increases with the temperature, from 3 to 4 times more than the resistance of the liquids decreases, their combined result may produce a reduction of the internal resistance, to some extent, with further decrease of intensity.

On page 388 I ought to have mentioned the so-called "Uebergangswiderstand," or resistance to passage from solids into liquids, as one of those circumstances which may influence, or bring forth the results of my experiments. However, from what I could learn about this kind of resistance, I at first could not make much of it. Fechner represented it as in direct proportion with the intensity of the current (see G. Wiedermann's Galvanismus, vol. i, page 449, which, however, is contradicted by De la Rive's Treatise, vol. ii, page 402). Such relation would not harmonize at all with my experiments. Poggendorff found the reverse to be the case; but the idea of such resistance was generally discountenanced, and the polarization was considered as sufficient to explain the whole matter, in most cases. To be sure, the existence of such resistance in other cases was acknowledged, and Neumann and Wild gave methods to determine it. Experimenting with a Daniell's battery, Neumann found the increase of this peculiar resistance to be in direct proportion with the intensity of the current. But I could not form any idea about the amount of this resistance compared with the common resistance of the liquids, since I had at hand nothing but a meager

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report about those experiments. Besides this, the figures given by Neumann were then (1857) not free from doubt as to their being increased on account of a possible neglect of a part of the polarization.

Apart from all these doubts, I have to confess it, the indiscriminate use of the formula E=IR was the chief reason of my neglecting the resistance to passage, "Uebergangswiderstand," since the electro-motive force of the battery seemed to increase in the same ratio as the internal resistance, and did so indeed if calculated from column (*a*), after the common method. Later, guided by the fact of the resistance of the copper wire, if calculated from low intensities, following its own course, and by the evident inconsistency of combining intensities widely differing from each other, I proposed to calculate the electro-motive force not with the direct intensity, but with those intensities every higher resistance is derived from. Taking table XII, as a specimen, there result from the first and last resistances of 14 columns, the following values for the electro-motive force:

(*a*)														
4·37														
4·31	3·86													
4·60		5·66												
			7·37											
				7·05										
					6·96									
						9·66								
							7·82							
								8·30						
									9·03					
										9·21				
											9·38			
												9·92		
													9·69	
8·77	8·95	9·16	9·29	9·34	9·41	9·48	9·48	9·53	9·56	9·58	9·63	9·67	9·62	

The mean of the first three values of column (*a*) is 4·42; the mean of the last six values is 9·67, the ratio of increase therefore equal 1 to 2·133. I could not venture to determine, without knowing exactly the influence of temperature, whether or not, this increase of electro-motive force is due, partly, or exclusively, to this influence of temperature upon the resistance of the unit of the rheochord, or to a loss of electro-motive force, which I suppose to occur at high intensities. But I expect that a closer investigation of the matter will support my views about this point.

With the foregoing examination of the electro-motive force, I hope again to have thrown some new light upon the reason of differences between the values of the electro-motive force of a battery, as given by different experimenters, or derived from different methods. The variations are here not so great as in case of the specific resistances; the electro-motive force of the Grove battery for instance, varying from 167 (Poggendorff's low-

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est figure) to ·192 Lenz and Saweljev), when the force of Daniell's battery is taken as 100. The reason for this small amount of variation however seems to be obvious. There are less observations recorded as in the other case, and perhaps mainly such results which were considered as "reliable," thus excluding extreme values which, under certain circumstances are liable to turn up.

If I take from the above table, 9·67 as an approximation to the true electro-motive force of the battery, the internal resistance of the battery, at common temperatures, would result as $\frac{9{\cdot}67}{0{\cdot}8865}=10{\cdot}9$, and the internal resistance would appear to increase from 10·9 to 21·30, or from 1 to 1·954, and this from some other reason than the influence of temperature upon the measuring rheochord wire. These figures however cannot convey a true idea of the relative importance of the temperature on one side, and of all the other reasons, if there exist more, for the increase of electro-motive force, and internal and external resistance, on the other side, since the simple formula of Ohm does not detail what is constant, and what undergoes variations in different degrees.

What this reason is I am still at a loss to know. I hold that it is not polarization. It seems very probable that the resistance to passage, "Uebergangswiderstand," will furnish the key to the results of my experiments. But it will require other experiments quite differently arranged and detailed to settle this question. I think it will no longer do to use Ohm's simple formula, and to permit the intensity of the current, and the temperature produced by it, to influence the determinations of electro-motive forces and resistances, to an unknown extent, and varying widely according to uncontrolled circumstances.

TABLE VI.

Battery, zinc in diluted sulphuric acid; gas coke in properly acidulated solution of bichromate of potash. Both liquids had been used once before.

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.		Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.	
0	23°	·4245	....			0	20·9	·3819	....		
2	20·6	·3759	$\frac{15{\cdot}47}{41{\cdot}76}$	28·61		2	19·4	·3521	$\frac{23{\cdot}63}{27{\cdot}29}$	25·46	
0	21·5	·3939	....			0	20·7	·3779	....		
2	19·6	·3561	$\frac{14{\cdot}9}{22{\cdot}39}$	18·65	25·69	2	19·1	·3462	$\frac{21{\cdot}84}{29{\cdot}21}$	25·52	25·00
0	21·2	·3879	....			0	20·3	·3699	....		
2	20·1	·3660	$\frac{33{\cdot}42}{26{\cdot}24}$	29·83		2	18·9	·3424	$\frac{24{\cdot}90}{23{\cdot}14}$	24·02	
0	21·5	·3939	....			0	20·4	·3720	....		
2	19·4	·3521	$\frac{16{\cdot}85}{23{\cdot}63}$	20·24							

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TABLE VI (continued).

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.		Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resist.	
0	20·4°	·3720	....			0	20·1	·3660			
4	18·6	·3365	37·91 / 42·73	40·32	36·5	4	17·7	·3191	27·21 / 26·10	26·65	28·42
0	20·2	·3680	....			0	20·2	·3680	....		
4	18·2	·3287	33·45 / 31·91	32·68		4	17·8	·3211	27·38 / 33·02	30·20	
0	20·3	·3699	....			0	19·8	·3600	....		
4	18·2	·3287	31·91 / 35·25	33·58							
0	19·8°	·3600	....			0	19·5°	·3541	....		
6	17	·3057	33·78 / 35·00	34·39	33·34	6	16·5	·2962	30·69 / 29·67	30·18	31·08
0	19·7	·3581	....			0	19·6	·3561	....		
6	16·8	·3020	32·30 / 32·30	32·30		6	16·6	·2981	30·84 / 33·12	31·98	
0	19·7	·3581	....			0	19·4	·3521	....		
6	16·3	·2925	26·75 / 28·49	27·62							
0	19°	·3443	....			8	15·6°	·2792	30·64 / 26·43	33·54	31·69
8	15·8	·2830	36·93 / 36·93	36·93	33·44	0	18·8	·3405	....		
0	19	·3443	....			8	15	·2679	29·25 / 28·05	28·65	
8	15·7	·2811	32·42 / 28·86	30·64		0	19	·3443	...		
0	19·4	·3521	....			8	15·3	·2736	30·96 / 34·79	32·87	
8	15·8	·2830	32·76 / 32·76	32·76		0	18·6	·3365	....		
0	19·4	·3521	....								
0	18·6°	·3365	....			0	18·8°	·3405	....		
10	14·4	·2567	32·17 / 29·30	30·73	31·36	10	14·6	·2605	32·56 / 31·09	31·82	31·75
0	19	·3443	....			0	19	·3443	....		
10	14·7	·2623	32·0 / 32·0	32·0		10	14·5	·2586	30·17 / 33·19	31·68	
0	19	·3443	....			0	18·6	·3365	....		
10	14·7	·2623	32·0 / 33·54	32·77							
0	18·6°	·3365	....			0	17·8°	·3211	....		
20	12·1	·2145	35·16 / 36·73	35·97	35·27	20	11·6	·2054	35·50 / 34·38	34·94	34·66
0	18·3	·3308	....			0	18	·3249	....		
20	11·8	·2089	34·27 / 34·87	34·57		20	11·6	·2054	34·38 / 34·38	34·38	
0	18·2	·3287	....			0	18	·3249	....		
20	11·6	·2054	33·32 / 35·50	34·41							

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TABLE VI (continued).

Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.		Rheochord.	Compass.	Tangent.	Int. resist.	Mean values of int. resistance.	
0	18°	·3249	....			0	18·2°	·3287	....		
30	10	·1763	35·59 / 34·23	34·91	37·33	30	9·85	·1736	33·58 / 35·79	34·68	34·37
0	18·3	·3308	....			0	17·7	·3191	....		
30	10·3	·1817	39·24 / 40·25	39·75		30	9·6	·1727	35·32 / 33·21	34·26	
0	18·1	·3268	....			0	18·2	·3287	....		
30	10·1	·1781	35·93 / 35·48	35·71							
0	18·2°	·3287	....			60	7·4°	·1329	44·64 / 44·64	44·64	41·37
40	8·7	·1520	34·41 / 35·96	35·18	34·72	0	17·3	·3115	....		
0	17·3	·3211	....			60	6·9	·1210	38·11 / —	38·11	
40	8·4	·1477	34·07 / 34·47	34·27		0*	16·4	·2943	....		
0	17·7	·3191	....			60	7·0	·1228	42·96 / 43·42	43·19	
40	8·6	·1513	36·96 / 37·33	37·15	36·09	0	16·3	·2925	....		
0	17·4	·3134	....			60	6·8	·1192	41·27 / 41·27	41·27	39·76
40	8·3	·1459	34·84 / 35·24	35·04		0	16·3	·2925	....		
0	17·3	·3115	....			60	6·5	·1139	38·26 / 38·26	38·26	
						0	16·3	·2925	....		
0	16·3°	·2925	....			0	16·1°	·2886	....		
120	4·3	·0752	41·53 / 41·19	41·36	41·35	120	4·1	·0716	39·59 / 39·95	39·77	39·57
0	16·4	·2943	....			0	16	·2867	....		
120	4·4	·0770	42·52 / 42·15	42·34		120	4	·0699	38·69 / 40·08	39·38	
0	16·5	·2962	....			0	15·6	·2792	....		
120	4·3	·0752	40·83 / 42·29	41·56							
0	15·6°	·2792	....			0	15·8°	·2830	....		
200	2·8	·0489	42·47 / 39·47	40·97	41·54	200	2·7	·0472	40·03 / 41·69	40·86	40·09
0	15·8	·2830	....			0	15·3	·2736	....		
200	2·8	·0489	41·78 / 42·47	42·12		200	2·6	·0454	39·79 / 38·84	39·32	
0	15·6	·2792	....			0	15·6	·2792	....		
200	2·7	·0472	40·69 / 41·48	41·08							

* This observation was made after the battery having been open for some time.

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TABLE VII. *Internal resistance.*

Rheochord.	Tangent.	(a)															(b)				
0	1·9820	....																			
10	1·8008	99·38	....																		
20	1·6689	106·60	116·52	....																	
30	1·5225	9[illegible]·41	99·41	84·	....																
40	1·4455	107·77	112·05	109·41	157·73	....															
50	1·3484	106·41	109·22	106·21	124·9	98·87	....														
60	1·2955	113·23	118·19	118·8	141·2	132·6	194·9	....													
70	1·2442	118·04	124·1	126·5	148·8	145·4	188·8	182·5	....												
80	1·1659	114·29	118·5	119·0	133·5	126·9	141·3	120·0	78·9	....											
90	1·1185	116·58	121·3	122·2	136·0	131·0	144·6	129·6	107·9	156·0	....										
100	1·0767	118·93	123·8	125·4	139·0	135·2	148·1	136·9	122·8	161·4	167·6	....									
110	1·0303	119·08	123·7	125·2	137·4	133·7	144·3	134·2	122·7	147·9	142·6	122·0	....								
120	·9939	120·70	125·5	127·2	139·2	136·1	146·2	137·7	128·5	151·1	149·3	140·1	163·0	....							
130	·9593	121·94	126·8	128·7	140·3	137·5	147·2	139·7	132·0	152·1	151·0	145·1	160·2	157·2	....						
140	·9320	124·27	129·4	131·7	143·6	141·5	151·4	145·1	138·9	159·0	159·9	157·6	174·4	181·1	211·3	....					
150	·8989	124·49	129·5	131·8	143·0	140·9	149·9	144·0	138·2	155·6	155·6	152·8	163·6	163·8	167·6	131·5	....				
160	·8773	127·06	132·5	135·1	146·7	145·2	154·8	149·8	145·2	163·2	164·6	164·0	176·6	181·0	190·7	180·7	256·1	....			
170	·8472	126·91	132·1	134·6	145·5	144·1	153·5	147·8	143·4	159·2	159·8	158·4	167·6	168·8	172·5	159·7	177·7	121·4	....		
180	·8260	128·61	134·0	136·8	147·8	145·0	155·5	151·1	147·2	163·0	164·1	163·5	173·0	175·1	179·8	171·7	189·9	162·0	219·6	....	
190	·8014	128·97	134·3	137·0	147·8	146·6	155·1	150·8	147·1	161·8	162·7	161·9	170·0	171·4	174·5	166·8	178·7	156·7	179·8	145·6	....
200	·7844	131·0	136·6	139·6	150·6	149·8	158·5	154·8	151·8	166·7	168·2	168·3	177·1	179·5	183·9	178·8	192·5	177·7	204·7	197·1	271·6
Mean values,		128·51	133·9	136·6	147·7	146·1	155·5	150·5	146·9	162·8	163·9	163·2	172·9	175·2	180·3	171·6	198·9	Mean value of all these figures, 183·6			

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TABLE VIII. (R.+Cu.) *Internal resistance, 200 centimeters of copper wire included.*

Rheochord.	Copper wire.	Tangent.	(Cu.) Resist. of the copper.	(R.) True inter. resistance.	(a)														(b)		
0	0	1·9820																			
0	200	·7844			....																
2	"	·6063	4·13	2·68	6·81	....															
4	"	·4751	3·92	2·43	6·35	5·24	....														
6	"	·4031	3·83	2·51	6·34	5·93	7·20	....													
8*	"	·3585	4·07	2·66	6·73	6·68	8·30	10·08	....												
10*	"	·3310	4·41	2·89	7·30	7·62	9·78	12·36	16·08	....											
12	"	·3042	4·59	3·01	7·60	8·07	10·24	12·45	14·41	12·25	....										
14	"	·2851	4·82	3·17	7·99	8·65	11·00	13·32	15·30	14·84	17·85	....									
16	"	·2614	4·82	3·17	7·99	8·61	10·67	12·44	13·54	12·53	12·43	8·06	....								
18	"	·2493	4·70	3·69	8·39	9·17	11·45	13·45	14·83	14·41	15·24	13·85	25·20	....							
20	"	·2401	5·33	3·49	8·82	9·80	12·35	14·82	16·33	16·41	17·96	18·00	28·62	34·2	....						
30	"	·1911	5·84	3·82	9·66	10·89	13·49	15·63	17·11	17·36	18·41	18·52	22·05	22·77	19·0	....					
40	"	·1575	6·07	3·98	10·05	11·33	13·85	15·80	17·09	17·23	18·06	18·25	20·38	20·61	18·13	16·88	....				
50	"	·1326	6·16	4·02	10·19	11·44	13·81	15·57	16·65	16·73	17·48	17·43	19·00	19·04	17·00	15·33	13·25	....			
60	"	·1158	6·42	4·12	10·54	11·69	14·41	15·76	16·81	16·90	17·50	17·46	19·01	19·03	17·34	16·13	15·54	18·93	....		
70	"	·1033	6·42	4·20	10·62	11·96	14·34	16·05	17·09	17·22	17·82	17·82	19·29	19·34	17·75	17·06	17·17	20·51	22·64	....	
80	"	·0910	6·34	4·16	10·50	11·77	14·00	15·57	16·49	16·54	17·02	16·94	19·35	18·14	16·62	15·46	14·73	15·62	13·38	40·0	
Mean values,					10·55	11·81	14·25	15·79	16·80	16·89	17·45	17·41	19·22	18·84	17·24	16·22	15·81	18·35			

* These lengths of the wire were hotter than shorter lengths, on account of conduction. 7·5 cm. length was the hottest, being very dark red.

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TABLE IX. *Internal resistance.*

Rheochord.	Tangent.	(a)																				(b)			
0	1·4322																								
6	·4672	2·91																							
8	·4083	3·19	7·86																						
10	·3730	3·52	9·84	13·13																					
12	·3413	3·76	10·27	12·37	11·53																				
14	·3165	3·97	10·80	12·69	12·41	13·52																			
16	·2931	4·12	10·83	12·35	12·01	12·32	11·05																		
18	·2772	4·32	11·50	13·14	13·15	13·95	14·21	18·87																	
20	·2595	4·43	11·49	12·93	12·86	13·38	13·32	14·89	11·32																
30	·2050	5·01	12·76	14·18	14·40	15·07	15·42	16·58	16·07	17·61															
40	·1687	5·34	13·22	14·53	14·77	15·37	15·68	16·54	16·20	17·16	16·47														
50	·1439	5·59	13·58	14·85	15·12	15·70	16·01	16·48	16·12	16·85	16·18	15·76													
60	·1263	5·80	14·01	15·29	15·60	16·19	16·50	17·31	17·15	17·93	18·14	19·57	24·73												
70	·1124	5·96	14·27	15·55	15·87	16·48	16·84	17·58	17·46	18·20	18·55	19·89	22·98	20·86											
80	·1008	6·06	14·36	15·60	15·92	16·50	16·85	17·55	17·43	18·11	18·37	19·38	21·32	19·06	16·90										
90	·0908	6·09	14·26	15·45	15·74	16·27	16·58	17·21	17·07	17·67	17·70	18·28	19·31	16·73	14·08	19·80									
100	·0827	6·13	14·22	15·36	15·64	16·14	16·42	17·01	16·86	17·42	17·33	17·70	18·34	15·87	13·53	11·38	12·1								
110	·0761	6·17	14·24	15·36	15·63	16·12	16·39	16·96	16·82	17·34	17·23	17·52	18·05	15·80	13·87	12·43	13·54	15·30							
120	·0715	6·31	14·60	15·77	16·09	16·62	16·93	17·55	17·54	18·00	18·20	18·85	19·80	18·28	17·40	17·61	21·14	27·68	45·43						
130	·0664	6·32	14·54	15·69	16·00	16·50	16·79	17·39	17·28	17·82	17·91	18·41	19·16	17·59	16·61	16·51	22·95	22·21	26·91	10·20					
140	·0621	6·35	14·54	15·68	15·97	16·47	16·76	17·33	17·22	17·75	17·80	18·25	18·91	17·38	16·42	16·28	18·19	17·23	23·07	12·13	14·42				
150	·0581	6·34	14·45	15·56	15·83	16·31	16·58	17·12	17·00	17·50	17·46	17·78	18·27	16·67	15·60	15·22	16·60	18·01	19·11	10·09	10·00	5·25			
Mean values,		6.34	14·51	15·64	15·93	16·43	16·71	17·28	17·17	17·69	17·72	18·15	18·78	17·31	16·31	16·00	19·25	19·15	23·03	10·81					

18·51

TABLE X. (R+Cu.) *Internal resistance, 25 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True inter. resistance.	(a)												(b)					
0	0	1·3223																				
25	0	1·1512																				
25	4*	·5375	·45	3·18	3·53	—																
25	6	·4519	·50	3·38	3·88	6·56	—															
25	8	·3992	·55	3·69	4·24	7·54	9·15	—														
25	10	·3615	·59	3·98	4·57	8·32	10·0	11·18	—													
25	12	·3315	·63	4·22	4·85	8·78	10·52	11·58	12·1	—												
25	14	·3063	·66	4·41	5·07	9·24	10·83	11·78	12·19	12·31	—											
25	16	·2863	·69	4·60	5·29	9·67	11·28	12·29	12·84	13·33	14·63	—										
25	18	·2690	·71	4·78	5·49	10·02	11·64	12·66	13·26	13·82	14·84	15·1	—									
25	20	·2534	·73	4·91	5·64	10·30	11·87	12·85	13·44	13·95	14·74	14·81	14·48	—								
25	30	·2017	·82	5·55	6·37	11·61	13·34	14·46	15·24	15·98	16·85	17·38	17·96	19·01	—							
25	40	·1674	·88	5·98	6·86	12·28	14·00	15·11	15·87	16·56	17·33	17·78	18·24	18·98	18·8	—						
25	50	·1434	·92	6·19	7·11	12·73	14·45	15·54	16·3	16·96	17·7	18·12	18·53	19·11	19·48	19·75	—					
25	60	·1244	·94	6·35	7·27	12·86	14·51	15·54	16·28	16·83	17·45	17·81	18·13	18·57	18·28	17·86	15·74	—				
25	70	·1109	·97	6·49	7·46	13·15	14·81	15·85	16·55	17·16	17·78	18·14	18·47	18·91	18·85	18·68	18·25	22·14	—			
25	80	·0996	·98	6·60	7·58	13·29	14·92	15·93	16·62	17·22	17·8	18·14	18·45	18·85	18·77	18·49	18·22	20·32	18·14	—		
25	90	·0919	1·00	6·81	7·81	13·73	15·44	16·52	17·27	17·92	18·57	18·98	19·36	19·83	20·22	20·86	21·38	24·83	26·74	39·35	—	
25	100	·0845	1·00	6·92	7·92	13·91	15·63	16·70	17·45	18·10	18·76	19·17	19·55	20·02	20·47	21·15	21·73	24·71	26·02	31·92	24·2	
Mean values for 50, 60 and 70,					7·28	12·91	14·59	15·64	16·36	16·98	17·64	18·02	18·33	18·86	18·87	18·83	Mean value of all other figures except the three of the two last columns, 21·52					
" " " 80, 90 & 100,					7·77	13·64	15·33	16·38	17·11	17·75	18·38	18·76	19·12	19·57	19·83	20·17						
" " " 50 to 100,					7·52	13·28	14·96	16·01	16·74	17·36	18·01	18·39	18·75	19·21	19·34	19·50						

* This length of platinum wire was heated dark red.

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TABLE XI. (R+Cu.) *Internal resistance, 50 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True inter. resistance.	(a)												(b)				
0	0	1·3062																			
50	0	1·0493																			
50	4*	·5212	·78	3·17	3·95	—															
50	6	·4399	·85	3·48	4·33	6·82	—														
50	8	·3886	·92	3·78	4·70	7·72	9·15	—													
50	10	·3535	1·00	4·08	5·08	8·64	10·36	12·14	—												
50	12	·3247	1·05	4·32	5·37	9·22	10·91	12·32	12·55	—											
50	14	·3008	1·10	4·52	5·62	9·65	11·3	12·56	12·83	13·17	—										
50	16	·2831	1·16	4·77	5·93	10·35	12·2	13·69	14·47	15·83	19·6	—									
50	18	·2670	1·21	4·93	6·14	10·7	12·53	13·95	14·69	15·76	17·6	15·6	—								
50	20	·2496	1·23	5·01	6·24	10·7	12·36	13·54	14·02	14·59	15·25	13·1	10·7	—							
50	30	·1974	1·37	5·58	6·95	11·85	13·53	14·71	15·29	15·91	16·52	15·95	16·08	17·81	—						
50	40	·1664	1·49	6·05	7·54	12·88	14·68	15·96	16·68	17·43	18·17	17·99	18·39	20·0	23·68	—					
50	50	·1419	1·54	6·28	7·82	13·21	14·95	16·11	16·82	17·5	18·15	17·97	18·29	19·52	21·11	17·92	—				
50	60	·1242	1·58	6·47	8·05	13·52	15·24	16·42	17·08	17·73	18·35	18·23	18·53	19·61	20·9	18·86	20·17	—			
50	70	·1110	1·63	6·65	8·28	13·86	15·6	16·79	17·46	18·12	18·75	18·66	19·0	20·04	21·39	20·11	21·84	24·09	—		
50	80	·0996	1·65	6·74	8·39	13·95	15·66	16·81	17·46	18·09	18·67	18·59	18·88	19·84	20·92	19·64	24·09	20·97	17·36	—	
50	90	·0908	1·67	6·85	8·52	14·14	15·84	17·0	17·65	18·28	18·86	18·79	19·1	20·02	21·1	20·05	21·07	21·56	19·9	23·18	—
50	100	·0827	1·68	6·87	8·55	14·1	15·76	16·87	17·48	18·07	18·61	18·52	18·79	19·64	20·47	19·28	19·84	19·71	17·7	17·87	12·1
Mean values for 50, 60 and 70,					8·05	13·53	15·26	16·44	17·12	17·78	18·42	18·28	18·61	19·72	21·13	18·96	Mean value of all other figures, except the last, 20·67.				
" " " 80, 90 & 100,					8·49	14·06	15·75	16·89	17·53	18·15	18·71	18·63	18·92	19·83	20·63	19·66					
" " " 50 to 100,					8·27	13·79	15·51	16·66	17·32	17·97	18·56	18·46	18·76	19·78	20·98	19·31					

* This length of platinum wire was heated but very dark red.

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TABLE XII. (R+Cu.) *Internal resistance, 100 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True inter. resistance.																			
0	0	1·3240			(a)																		(b)
100	0	·8865																					
100	2*	·6307	1·63	3·30	4·93	—																	
100	4	·4863	1·61	3·25	4·86	4·12	—																
100	6	·4150	1·75	3·53	5·28	5·69	7·64	—															
100	8	·3730	1·92	3·89	5·81	6·68	9·17	11·76	—														
100	10	·3373	2·03	4·11	6·14	7·19	9·58	11·86	10·9	—													
100	12	·3075	2·10	4·27	6·37	7·51	9·76	11·16	10·77	10·64	—												
100	14	·2891	2·24	4·53	6·77	8·15	10·66	12·37	12·67	13·99	19·42	—											
100	16	·2692	2·30	4·67	6·97	8·42	10·88	12·46	12·74	13·71	16·11	13·05	—										
100	18	·2528	2·37	4·81	7·18	8·70	11·15	12·70	13·08	13·93	15·73	13·86	14·83	—									
100	20	·2394	2·44	4·95	7·39	9·01	11·51	13·09	13·5	14·45	16·12	14·9	16·13	17·73	—								
100	30	·1900	2·70	5·51	8·21	10·07	12·67	14·26	14·84	15·79	17·1	16·67	17·58	18·3	18·46	—							
100	40	·1580	2·86	5·81	8·67	10·7	13·32	14·9	15·51	16·43	17·58	17·33	18·1	18·66	18·83	19·4	—						
100	50	·1363	3·00	6·08	9·08	11·23	13·91	15·51	16·18	17·12	18·25	18·11	18·87	19·44	19·66	20·76	22·81	—					
100	60	·1195	3·08	6·26	9·34	11·55	14·24	15·83	16·51	17·43	18·51	18·41	19·12	19·65	19·86	20·85	22·08	21·13	—				
100	70	·1071	3·18	6·44	9·62	11·91	14·64	16·26	16·97	17·91	18·99	18·95	19·68	20·22	20·47	21·68	23·12	23·35	26·37	—			
100	80	·0954	3·19	6·45	9·64	11·9	14·55	16·00	16·74	17·6	18·58	18·50	19·13	19·57	19·75	20·42	20·95	19·97	19·17	11·54	—		
100	90	·0873	3·25	6·58	9·83	12·14	14·81	16·38	17·05	17·93	18·92	18·87	19·51	19·98	20·17	21·0	21·74	21·26	21·33	18·18	27·77	—	
100	100	·0796	3·27	6·62	9·89	12·19	14·83	16·38	17·08	17·89	18·84	18·78	19·39	19·82	20·0	20·69	21·22	20·62	20·40	17·69	22·31	16·4	
0	100	·0832																					
Mean values for 50, 60 and 70,					9·35	11·56	14·26	15·87	16·55	17·49	18·58	18·49	19·22	19·77	20·00	21·10	22·67						
" " " 80, 90 & 100,					9·79	12·08	14·73	16·28	16·94	17·81	18·73	18·72	19·34	19·79	19·97	20·70	21·30						
" " " 50 to 100,					9·57	11·82	14·49	16·07	16·74	17·65	18·66	18·60	19·28	19·78	19·98	20·90	21·99						

Mean value of all other figures, except the last one, 20·79.

* This length of platinum wire did not show any sign of dark red heat.

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TABLE XIII. (R+Cu.) *Internal resistance, 150 centimeters of copper wire included.*

Copper wire.	Rheochord.	Tangent.	(Cu.) Resistance of the copper wire.	(R.) True inter resistance																						
0	0	1·2877			(a)																					(b)
150	0	·7492																								
150	2	·5714	2·68	3·74	6·42	—																				
150	4	·4676	2·78	3·86	6·64	7·0	—																			
150	6	·3972	2·83	3·94	6·77	7·12	7·28	—																		
150	8	·3536	2·99	4·16	7·15	7·74	8·4	10·29	—																	
150	10	·3247	3·19	4·45	7·64	8·53	9·63	11·91	14·47	—																
150	12	·2974	3·30	4·59	7·89	8·85	9·98	11·88	13·16	11·78	—															
150	14	·2792	3·53	4·84	8·32	9·46	10·82	12·98	14·51	14·54	18·68	—														
150	16	·2606	3·57	4·96	8·53	9·74	11·11	13·07	14·41	14·4	16·32	14·02	—													
150	18	·2462	3·68	5·13	8·81	10·11	11·57	13·56	14·92	15·09	16·85	15·84	18·19	—												
150	20	·2343	3·81	5·29	9·10	10·51	12·07	13·89	15·56	15·91	17·70	17·31	19·68	21·38	—											
150	30	·1860	4·14	5·76	9·90	11·51	13·17	15·13	16·41	16·82	18·05	17·98	18·90	19·07	18·51	—										
150	40	·1551	4·37	6·07	10·44	12·16	13·77	15·74	17·0	17·43	18·51	18·49	19·28	19·45	19·16	20·19	—									
150	50	·1339	4·55	6·33	10·88	12·69	14·46	16·37	17·6	18·07	19·12	19·17	19·98	20·15	20·01	21·4	23·16	—								
150	60	·1174	4·66	6·49	11·15	13·0	14·77	16·66	17·84	18·31	19·30	19·37	20·07	20·28	20·17	21·34	22·28	21·15	—							
150	70	·1051	4·78	6·64	11·42	13·32	15·13	17·03	18·22	18·71	19·69	19·81	20·49	20·73	20·67	21·96	23·06	22·98	25·44	—						
150	80	·0941	4·80	6·69	11·49	13·37	15·14	16·97	18·11	18·56	19·47	19·55	20·17	20·35	20·27	21·41	21·7	20·93	20·77	15·54	—					
150	90	·0866	4·92	6·84	11·76	13·72	15·54	17·42	18·6	19·09	20·04	20·17	20·83	21·07	21·04	22·27	23·21	23·23	24·35	23·62	35·46	—				
150	100	·0787	4·91	6·83	11·74	13·65	15·42	17·22	18·34	18·80	19·66	19·75	20·34	20·53	20·46	21·34	21·81	21·29	21·34	19·43	22·21	9·62				
0	100	·0824																								

Mean value of all other figures except the last one, 22·39.

Mean values for 50, 60 and 70,	11·15	13·0	14·79	16·35	17·89	18·36	19·37	19·45	20·16	20·39	20·28	21·57	22·83		
" " " 80, 90 & 100,	11·66	13·58	15·03	17·14	18·35	18·82	19·72	19·82	20·45	20·65	20·59	21·67	22·24		
" " " 50 to 100,	11·40	13·29	14·91	16·75	18·12	18·59	19·55	19·64	20·30	20·52	20·43	21·62	22·53		

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TABLE XIV. (R+Cu.) *Internal resistance, 200 centimeters of copper wire included.*

Copper wire.	Rheostat.	Tangent.	(Cu) Resistance of the copper wire.	(R) True internal resistance.	(a)																				(b)				
0	0	1·2544																											
200	0	·6611																											
200	2	·5233	3·59	4·0	7·59	—																							
200	4	·4305	3·53	3·94	7·47	7·28	—																						
200	6	·3758	3·74	4·16	7·90	8·19	9·74	—																					
200	8	·3397	4·00	4·45	8·45	9·10	10·85	12·82	—																				
200	10	·3098	4·17	4·65	8·82	9·56	11·40	12·77	12·72	—																			
200	12	·2868	4·35	4·84	9·19	10·13	11·97	13·34	13·68	14·94	—																		
200	14	·2681	4·52	5·03	9·55	10·61	12·51	13·91	14·47	15·72	16·67	—																	
200	16	·2504	4·61	5·14	9·75	10·85	12·68	13·97	14·43	15·29	15·52	14·29	—																
200	18	·2358	4·73	5·26	9·98	11·12	12·97	14·21	14·69	15·49	15·74	15·20	16·30	—															
200	20	·2262	4·92	5·48	10·40	11·70	13·71	15·17	15·91	17·06	17·86	18·39	21·30	29·12	—														
200	30	·1806	5·34	5·94	11·28	12·76	14·79	16·21	16·97	17·95	18·61	19·02	20·22	21·26	19·6	—													
200	40	·1514	5·62	6·26	11·88	13·47	15·53	16·94	17·73	18·67	19·31	19·73	20·70	21·46	20·48	21·85	—												
200	50	·1282	5·69	6·34	12·03	13·57	15·51	16·78	17·46	18·24	18·72	18·99	19·67	20·13	19·24	18·93	15·26	—											
200	60	·1149	5·97	6·65	12·62	14·32	16·39	17·78	18·58	19·47	20·08	20·50	21·31	21·91	21·29	22·47	22·96	36.39	—										
200	70	·1016	6·01	6·70	12·71	14·38	16·39	17·72	18·46	19·28	19·82	20·17	20·87	21·37	20·77	21·44	21·2	26·39	16·39	—									
200	80	·0901	5·97	6·65	12·62	14·22	16·11	17·34	17·99	18·71	19·15	19·41	19·97	20·34	19·72	19·78	18·79	20·94	12·66	17·04	—								
200	90	·0828	6·09	6·79	12·88	14·31	16·48	17·74	18·43	19·18	20·12	19·96	20·56	20·96	20·42	20·8	20·35	22·95	17·38	18·06	33·42	—							
200	100	·0777	6·30	7·02	13·32	15·09	17·14	18·50	19·28	20·13	20·70	21·09	21·79	22·30	21·9	22·85	23·26	26·93	23·55	27·53	45·32	62·35							
0	100	·0794																											
Mean values for 50, 60 and 70,					12·45	14·09	16·1	17·43	18·17	19·0	19·54	19·89	20·62	21·14	20·43	20·95	19·81	Mean value of all other figures except the last one, 23·44.										
"	"	" 80, 90 & 100,			12·94	14·54	16·58	17·86	18·57	19·34	19·99	20·15	20·77	21·20	20·68	21·14	20·80											
"	"	" 50 to 100,			12·69	14·31	16·34	17·64	18·37	19·17	19·76	20·02	20·69	21·17	20·56	21·04	20·30											

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ART. VIII.—*On Colorado Meteorites—Russel Gulch Meteoric Iron, and Bear Creek Meteoric Iron;* by Prof. J. LAWRENCE SMITH, Louisville, Ky.

THE first of these irons I described in the September number of this Journal, calling it the "Colorado meteorite." Owing to the discovery of another in the same territory (specimens of which have been in my possession for some little time), it will be proper to designate the first mass as the "Russel Gulch" iron and the other as the "Bear Creek" iron. Of this last there are two short notices in the November number of this Journal, pages 260 and 286, the specimen of it in my possession has enabled me to make a thorough examination of the constituents. The piece I have has a portion of the exterior attached.

As has already been stated by Prof. Shepard, it is coarsely crystalline, and laminated from the effects of decomposition between the crystals; the surface contains considerable pyrites, although Prof. Shepard did not discover any in his specimen. I was enabled to separate and analyze magnetic pyrites, schreibersite and nickeliferous iron. Of the magnetic pyrites sufficient was separated to make a quantitative determination which was as follows:

Sulphur,	35·08
Iron,	61·82
Nickel,	·41
Insoluble residue,	1·81
	99·12

The schreibersite was not obtained in sufficient quantity for a complete analysis; about 50 milligrams of the pure mineral gave all the constituents usually found in this interesting mineral.

The nickeliferous iron, constituting of course the great bulk of of the mass, was composed as follows:

Iron,	83·89
Nickel,	14·06
Cobalt,	·83
Copper,	minute quantity
Phosphorus,	·21
	98·99

The laminæ of iron are often very brilliant, having the luster of silver and caused me to suspect more nickel than was found. It was supposed that in the decomposition of the crystals the iron would disappear more rapidly than the nickel, and that by a process of cementation, the nickel would accumulate in the

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laminæ; but from careful examination of the process of decomposition, there is no doubt that the interior of the mass will not differ materially in its composition from the analysis already given of the nickeliferous iron. Besides the minerals already mentioned, and which properly belong to the original mass, there is much oxyd of iron, containing some nickel arising from the decomposition of the surface.

ART. IX.—*On a new locality of Tetrahedrite, Tennantite, and Nacrite, with some account of the Kellogg Mines of Arkansas;* by Prof. J. LAWRENCE SMITH.

A SHORT time since Prof. E. T. Cox of Indiana sent to me an antimonial copper ore containing silver, one fragment being the termination of a crystal having a number of small but beautiful faces, another was a minute crystal of a different form; in the hands of Prof. Cox a blowpipe analysis had given about five per cent of silver in some of the mineral.

The crystalline fragments were first examined and they enabled me clearly to trace out tetrahedrite in one and tennantite in the other. The faces on the tetrahedrite were small but beautiful and very numerous; from the number on the fragment examined there would not have been less than from 60 to 70 had the crystal been perfect: it corresponds very nearly to the cyrstal figured in Dufrenoy's Mineralogy, plate 124, fig. 441, which he speaks of as coming from Moschellandsberg, a locality that I am not able to discover. Good measurements were made on a few of the faces.

P on P 70°; P on b^3 159° 30′; P on a^2 144° 30′

Specific gravity of different specimens varied from 4·78 to 5·08; the latter was the sp. grav. of the above crystal. The analysis of two specimens, No. 2 being a part of the crystal, gave

	1.	2.
Antimony,	26·50	27·01
Sulphur,	26·71	25·32
Copper,	36·40	33·20
Iron,	1·89	·82
Zinc,	4·20	6.10
Silver,	2·30	4·97
Arsenic,	1·02	·61
	99·02	98·03

The quantity of No. 2 analyzed did not exceed 300 milligrams.

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There are two minerals consisting of minute micaceous scales on the quartz containing this gray copper. One of them I could not obtain in sufficient quantity for examination; from an imperfect examination I conclude that it is muscovite; the other mineral, a soft unctuous talc-like mineral, is nacrite, composed as follows:

Silica,	65·02
Alumina,	26·11
Oxyd of iron,	2·20
Manganese,	*trace*
Potash and soda,	1·18
Water,	4·98
	99·49

These minerals came from an exceedingly interesting mine in Arkansas that is as yet almost unexplored; I have obtained a full description of it from Prof. Cox and I think it would be well to give it here, for besides being likely to prove of considerable commercial value when properly explored, there will doubtless be found many interesting mineral species there.

The Kellogg mines are situated 10 miles north of the city of Little Rock in Pulaski Co, Ark. The country in the vicinity is rolling, the highest hills are about 270 feet above the water level of the neighboring streams. The surface rocks are thick and thin beds of sandstone alternating with shales occupying the base of the coal measures. The rocks are but little disturbed and are for the most part horizontal. There are no metamorphic rocks showing themselves at the surface nearer than Little Rock on the south side of the Arkansas river. Innumerable veins of milky quartz are seen traversing the sandstones and shales.

About seventeen years ago lead ore was discovered at these mines by Mr. Kellogg, companies were organized and mining operations carried on extensively for about one year, when the flattering accounts of the gold discoveries in California caused the miners to leave, and the work which had been badly conducted was abandoned. Many tons of the ore which is an argentiferous galena (containing 60 to 200 ounces of silver to the ton) were extracted from the mine and finally the greater part was shipped to England and sold at a good price. A smelting furnace has been erected on the grounds, but for lack of skill, the proprietor never succeeded in working the ore profitably, consequently the impression was produced that the ore could not be smelted, but there is no good reason for such an opinion.

Since the mines have been abandoned, the old shafts, ranging in depth from fifteen to seventy feet, are all filled in, and the country has become covered with a dense undergrowth of brush

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and briars. About one year ago Prof. Cox revisited these mines for a company who had in view to lease or purchase them; it was during this visit that the gray copper above referred to was discovered. This ore has previously escaped the observation of others who had explored these mines. It is impossible at present to see the ore in place, and those who previously worked the mine give conflicting statements as to the manner in which the ore is found.

The vein-rock and associated minerals with the galena are white quartz, spathic iron, zinc blende, copper pyrites, gray copper, tennantite and nacrite.

The mines are now in the hands of a new company, and the latest information from their operations are, that matters look well; the vein now being worked is nearly three feet wide, principally lead ore, the balance being zinc blende; twenty hands are at work, and the shaft is down forty-five feet. My opinion is, that in time this mine will become of considerable importance, and lead to further developments of argentiferous galena in that region.

ART. X.—*On recent Soundings in the Gulf Stream.*—Abstract of a paper read before the National Academy of Sciences; by HENRY MITCHELL, Assistant U. S. Coast Survey.

EARLY in the spring of the present year an application was made to the Coast Survey by the International Ocean Telegraph Company for information relative to the form and character of the bottom of the Straits of Florida between Key West and Havana along the proposed track of the submarine telegraph cable which is to connect the United States with the West India Islands. It was clearly the province of the Coast Survey to supply information of this sort, and a special survey was therefore ordered under instructions from Mr. J. E. Hilgard who, during the illness of Prof. Bache, conducts the work of this bureau. These instructions were carried out carefully and under favoring circumstances, so that the results are entitled to confidence.

The distance from Sand Key, on the extreme southern point of the Florida reef to El Moro rock at the entrance to Havana, is but a trifle over 82 miles. To lay a cable over this short distance would seem to be an easy task and one that should long since have been executed. In fact, however, the locality offers a new problem to the engineer, viz: *to lay a cable nearly at right angles to a strong stream, or system of streams, flowing through a rocky pass of great depth.* The new survey, if it does not, as is hoped, supply the elements for the solution of this problem, at

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least develops and gauges the difficulties of the task, and incidentally adds a few items of interest to physical inquiry.

The line of maximum depression was struck at a point 24 miles north of the Moro, and followed some distance to the northeast with depths of 853, 845 and 794 fathoms. The direction of this line does not correspond to that of the Gulf Stream in this neighborhood; but a glance at the map will show that a S.W. course would be a natural one for the *Polar Current*, as it is called, which runs near the bottom.

The numerous soundings of this survey make it possible to develop a profile of section from Sand Key to the Moro, and the subjoined table gives the numerical data for such a profile.

Section of Soundings across the Straits of Florida, from Sand Key to El Moro.

	Points on profile.	Distances from Sand Key.	Distances from El Moro.	Depths. By Indicator.	Depths. By outrun of line.	No of stations used.	Kind of bottom.	Remarks.
Northern approach to channel.	A	2¾	79½		65		rock.	Coral strewn over with shells.
	B	7½ to 8½	74½	111	125	5	"	Specimen of coral debris obtained.
	C	11	714	129	132	1	"	
	D	14½	67¾	289	309	2	"	Specimen of coral debris.
	E	18¼	64	369	397	1	mud.	Specimen of gray mud.
	F	24¼	58	432	466	1	"	Specimen of mud nearly white.
	G	29½	53½	504	553	2	"	Specimen nearly white with dashes of red.
	H	34	48¼	687	No indication of depth by the outrun of line.	1	"	Specimen of stiff mud, nearly white.
	I	38	44¼	794		1	"	Specimen gray and granular mud.
Southern approach to channel.	i	45½	36¾	845		1	"	Specimen nearly white with red tinge.
	h	51¼	31	842		3	"	Specimen same as above.
	g	55¾	26½	813		2	"	Specimen same as above.
	f	60	22¼	455		2	"	Specimen of mud with drab color.
	e	61¼	20¾	380		1	"	No specimen—some doubt of cast.
	d	67¼	15	710		1	hard.	
	c	73¼	9	748		1	mud.	
	b	78½	3¾	583	620	1	sand.	Sand or mud of reddish brown hue.
	a	80½	1¾	243	244	1	rock.	A small shell obtained.

In this profile, which is, strictly speaking, that of a diagonal section, the point of maximum depression is found 37 miles from the Moro, and is 843 fathoms. The approaches to the great valley from the two coasts are dissimilar in general features. From the northward the bottom falls away in *terraces* whose intervening slopes are nowhere abrupt; while from the southward an irregular and hilly approach is found with indications of abrupt if not precipitous changes of elevation. Above the terraces of the north shore the sea lies almost motionless, while among the cañons of the southern half of the Straits flow the Gulf Stream and its counter currents.

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These natural distinctions authorize us in taking up separately the descriptions of these approaches, and we shall proceed to do so briefly, commencing at Sand Key and following the profile southward from A to I: then commencing at the Moro and following northward from *a* to *i* (see table).

Northern Approach.—Leaving Sand Key, the water deepens rapidly to 13 fathoms, then shoals again to 7 fathoms upon a coast bar or ridge parallel to the reef, and scarcely ¾ths of a mile distant from it. Seen from the deck of a ship upon a fine day this bar is marked by a narrow belt of pale blue-green water in beautiful contrast with the dark blue-black of the ocean. The bottom can be seen on crossing it and appears to be a pure white rock *in situ*, strewn sparsely over with fragments of the weathered and brown reef rock. Two miles farther out carries us to the point A, where our table for the profile commences with sixty five fathoms of water on a slope of one foot in thirty seven. The next points B and C lie upon a nearly level plain which terminates about twelve miles from the reef in a slope of one foot to twenty-two. Upon this terrace numerous soundings were made covering about eight miles of longitude, which show that the formation belongs to the reef system and lies parallel to it. Chips of white coral rock were brought up in one of the casts—in all of them the hard bottom was felt by the hand. At what appears to be the foot of the fore slope of this terrace (point E) the bottom is found to be soft mud, and a specimen procured proved to be of a grey color quite in contrast both as regards color and consistency, with that obtained above or beyond. It differed from the white muds beyond, of which we shall hereafter speak, in possessing a granular character and retaining the same when dry. It is conceived that this terrace was once a dry reef covered over like Sand Key with dark fragments of agglomerated reef rock, and that a subsequent submergence has caused all this loose and weathered material to be swept down to the foot of the fore slope.

Between D and E, in about 300 fathoms, the *swept* portion of the Florida Reef, if not also the *base* of the formation, is passed. At F, G and H the bottom is of nearly white mud, with dashes of red at the last named point. These muds were found to *set* on drying. The mud with dashes of red is supposed to be the debris of a kind of coral, quite common upon the reef, which is spotted as if with drops of blood. These three stations seem to comprise another grand terrace, because at the 500 fathoms curve there seems to be a considerable belt where a difference of a mile in latitude or longitude scarcely altered the soundings. If this is so, we must suppose that we are not yet beyond the reef and that the rock still underlies the material which the specimen cup procures. *At the foot of the fore slope of this second terrace* (I)

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in 794 fathoms, the mud is again grey and *granular* while the next station beyond is of the ordinary white tinged with red.

Do these features belong to the history of the Gulf Stream or to the geology of the coral reef? As these slopes and terraces are now scarcely traversed by the streams, we are inclined to regard them as exhibiting the order in which, through successive ages, the reef has alternately subsided and stood still. As far as the swept portion of the reef apron extends, we see no indications of any caving down of the structure; and in the neighborhood of the second terrace the presence of mud forbids the supposition of long continued abrasion.

Southern Approach.—The Moro Rock is nearly perpendicular at the water line but retreats at points higher up. Its northwest profile is convex with a mean dip of 45° from the castle wall to the sea. Leaving this rock and advancing 1¾ miles northward, the bottom declines 1 foot in 7 to point *a*, where the depth is 243 fathoms and the bottom, *rock*. From *a* to *b* the depth increases very rapidly, 1 foot in 6, and the foot of the Moro Rock is passed. The bottom at *b* is a reddish brown mud which becomes in part granular on drying—*in many respects it resembles the specimens from the foot of the fore slope of the coral terrace on the north bank of the straits.* It is no doubt weathered debris swept down from the Moro.

The dip of the rocky part of this space between *a* and *b* is unquestionably much more precipitious than the mean we have stated, because 1 foot in 6 is altogether too great an inclination for the material found at *b*.

Beyond *b* the slope is gradual, 1 foot in 32, and terminates at *c* in the nearly horizontal bed of a depression which we shall call the Moro Channel. Here at *c* the depth is 748 fathoms. Six miles farther carries us across the Moro Channel and we find the depth a trifle more shallow, 710 fathoms, at *d*.

At *e* and *f* we find ourselves near the summit of a submarine mountain whose height above the bed of the Straits is about twenty four hundred feet. This mountain, lying but a few miles to the northward of the axis of the Gulf Stream, may be claimed as a point of decided interest in this survey. It is scarcely twenty one miles from the shore of Cuba whose hills are in full view if the weather is fine. Six casts were made upon its summit under the greatest difficulties, owing to the current. Only three of these proved successful and but one yielded a specimen of bottom. The depth on the summit was found to be about 400 fathoms. On looking over the work of former years we find that Capt. B. F. Sands in 1858 made deep sea soundings in this locality, and that he struck one sounding of 320 fathoms on the same parallel, but some twelve miles to the westward. He procured a specimen and observed the temperature to be 60°

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which is the usual amount for this depth in the Straits of Florida. The Polar current which underlies the stream, following the line of maximum depression, has a temperature of less than 45°. At first thought, it might be supposed that an obstacle in the track of the stream would cause an ascension of the Polar current, but when we consider that this Stream Bank has not the nature of a bar, and that the deep channel way beyond is ample, there would seem to be no reason for an ascension of the cold waters in this neighborhood.

Several other casts, not referred to in our table, because too far to the eastwasd of the section line, furnish some clue as to the form of the Stream Bank. It appears to be triangular in its general figure, presenting at its west angle a bold prow to the stream. As the current is here flowing with an accelerating velocity, a *deposit* is impossible. This bank, it appears to us, must have, like the adjacent reef, a firm constitution. It is an interesting question whether it belongs to the mountain system of Cuba (as its line of least water running E. and S. E. might seem to indicate), or whether it is an ancient reef now wearing and crumbling away. The least depth is about that of the foot of the *swept* portion of the reef apron on the north side of the Straits —it may indicate the true depth of the Gulf Stream itself, and if so, its summit is not now abraded, while its base must be wearing away under the action of the Polar current. A bank so situated must have precipitious slopes.

Observations upon the trend of the lead line, on hauling in, furnish indications that the thickness of the upper moving stratum, i. e., the depth of the Gulf Stream, is scarcely more than one third of the maximum depth of the channel. This stream seems to be an *overflowing* of water, not a profound movement. In the exchange between the Gulf of Mexico and the Atlantic, the office of the Gulf Stream appears to be the *restoration of surface level*, while the office of the counter stream, ("Polar current") below, is the *restoration of equilibrium thus disturbed*, between waters of different specific weights or densities. To illustrate this view of compensating currents, we may be suffered to recall an instance from our experience in observations at the mouth of Hudson River. In the dry season (July) the surface *outflow* (brackish) through the Narrows of New York harbor, occupies nine out of the twelve tidal hours, while in the lowest water stratum the case is more than reversed, the *inflow* (salt) predominates to that extent, that as a general thing it is *continual* along the bottom, although not *constant* in velocity. The same conditions, with variable proportions, were followed some distance up the river. On running a line of levels from New York city to Albany it was found that the bed of the Hudson lies below the *mean level* of the sea for over a hundred miles; but that the sur-

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face of the fresh water, even in the dry season, is above this level—not so much above, however, as to *equalize the difference of specific weight between it and the sea water*, so that the latter, during the summer months, flows in along the bed of the stream, while the former *overflows* into the ocean.

In the recent survey, observations upon surface densities were carried over several hundred miles. These show decided contrasts between the ocean and the stream, but no greater than the differences of temperature might lead us to expect.

The Gulf Stream is essentially confined to the southern half of the Strait in the portion crossed by this survey, but no westwardly drift along the north shore was observed except at one time a feeble flood tidal current setting close along the reef. It is not impossible that the widths of the Gulf Stream vary, as its velocities are known to do, and both of these may in many cases depend upon long continued gales of wind. During the period of the recent survey, however, the weather was exceedingly calm in the Gulf, and as far as learned, generally quiet at sea, yet the velocities of the stream altered in a marked manner, and so much so that the changes became a matter of comment among pilots and ship masters arriving at Havana. It would be exceedingly interesting and practically useful to ascertain from systematic inquiry the order of these variations. We would suggest as a reasonable hypothesis that these variations follow those changes of *mean-sea-level* which depend upon the declinations of the sun and moon—more especially the latter. There are no two seas upon the earth whose tidal phenomena differ more essentially than those of the Gulf of Mexico and the Atlantic Ocean; and it is a matter of certainty that the elevations of these two bodies of water are not affected in the same manner and degree by the half-monthly changes of the moon's declination. Professor Bache's paper on the "Tides of Key West," published in the Coast Survey Report of 1853 shows that the *mean level* of this station is one foot higher when the moon is in the equator than when she is at her greatest declination. In the North Atlantic the order is the reverse of this; the mean level is there about three inches higher at the maximum than at the zero declination.* Small as these relative changes of elevation may seem they must bear a large proportion to the total head of the Gulf Stream which suffers exceedingly little resistance in its course.

* From computations of the Coast Survey, and from Phil. Trans. R. S., 1839.

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ART. XI.—*Observations upon the Glacial Drift beneath the bed of Lake Michigan, as seen in the Chicago Tunnel;* by E. ANDREWS, A.M., M.D., Prof. of Surgery in Chicago Medical College.

IN the November number of this Journal there is an article from E. W. Hilgard, State Geologist of Mississippi, which contains serious errors respecting the Drift formation in Illinois. The mistakes occurred, doubtless, because the distinguished author had not an opportunity for personal observation here, and was obliged to rely on the information of others less competent than himself.

He remarks that the erratic blocks are nearly all well water-worn, and that the drift "is more or less irregularly, but distinctly, *stratified*," and that "*no glacier scorings* are mentioned either on the pebbles or on the adjacent rocks."

The truth is this. The drift of Illinois, Indiana, Michigan and Wisconsin consists of two distinct formations, one above the other. The lower is the well known "glacial drift" of authors. It is a heterogeneous mass, full of boulders and pebbles, which are only imperfectly rounded and sometimes quite sharp at the edges. Vast multitudes of the larger blocks are scratched and polished on one side by unmistakable glacier action. In a large part of the formation it is extremely difficult to discover any traces of stratification, though it can be noticed by great care.

The second formation always overlies the former, and consists of sand and gravel distinctly stratified, and filled with well rounded and water-worn pebbles. The two deposits are so unlike each other that there is no possibility of confounding them. Their relation to each other is best shown in the numerous railroad cuts which traverse them. It is there seen that at a distance from the valleys of streams, the old glacial drift usually comes to the surface, and often rises into considerable eminences. In Illinois, at least, the closest scrutiny generally fails to discover in it any stratification. As we approach the streams, however, the glacial drift sinks out of sight, and is overlaid by perfectly well stratified sand and gravel. The latter exists in enormous quantities, sometimes bordering the valley miles in width, and by its thick masses fully maintains the general height of the country. At the border of the valleys of the streams the sand and gravel suddenly cease, terminating in an abrupt descent; or perhaps the lower strata may continue beneath the alluvium of the bottom lands.

The Chicago tunnel is excavated for two miles in the glacial drift beneath the bed of Lake Michigan. It has been closely watched by a committee of the Chicago Academy of Sciences, as well as by Mr. Chesborough the city engineer, Mr. Kroeshell the

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inspector, and Mr. Gowan the contractor. From my own personal observation, and from those of the above-mentioned gentlemen, I derive the following facts. The tunnel is to supply the city with fresh water drawn from the lake at a distance of two miles from the shore. For this purpose a coffer dam was erected in the lake, two miles from the land, and within it a shaft was excavated in the clay to the depth of about seventy-five feet below the surface of the water. A similar shaft was sunk at the shore end, and from the bottoms the workmen drifted horizontally until they met beneath the lake.

The shaft at the shore end descended first through beach sand and then through tough clay, mostly free from boulders, and apparently a deposit from the lake. At the depth of about sixty-two feet the workmen came suddenly upon the hard glacial drift, containing glacier-scratched boulders, and in every way very different from the clay above it. The material appeared to be a soft comminuted shale reduced to a clay by the same means which transported it from its original strata. Every cubic yard of it contained millions of broken and scarcely rounded little fragments of the shale. These were accompanied with larger blocks of it, mixed with glacier-scratched boulders of limestone, sandstone, granite, syenite, and every other kind of rock which exists in the regions north of us. In this and similar material the whole of the rest of the shaft and the entire two miles of the horizontal part of the tunnel was excavated. Some extremely interesting facts were observed. For instance, this hard clay showed no trace of stratification when any particular part of it was inspected, yet it was so intercalated with other beds as to clearly prove its right to be called a stratum. After sinking eleven feet through it the workmen came to a thin bed of clay free from boulders, and beneath that to a stratum of sand, six inches in thickness, with another layer of hard clay beneath that. This stratum of sand was traced horizontally for over a thousand feet, when it ascended and disappeared through the roof of the excavation. Several hundred feet farther on another thin stratum of sand was struck whose upper surface clearly showed *ripple marks*. It was singular to observe that the clay resting upon it preserved a perfect cast of the ripple marks after the sand was removed from beneath it. This stratum extended only about fifty feet, when it thinned out and disappeared. About six thousand feet from the shore a stratum of softer clay entered the roof of the excavation, resting upon the hardpan beneath. Both formations contained boulders. These two strata followed so exactly the level of the tunnel that their junction was traced for four thousand feet farther, and was only lost at the outer extremity of the work, two miles from shore. It would seem therefore that in spite of the absence of minute

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layers in the clay, the stratified character of the whole mass is clearly made out.

The most surprising phenomenon discovered, was the existence all through the glacial drift, of numerous isolated "pockets" or cavities filled with stratified gravel. These "pockets," as the workmen called them, lay in all imaginable positions, sometimes with their strata set up at high angles. They were generally from a few inches to a few feet in diameter, and terminated abruptly on all sides in the solid impermeable clay. The gravel was water-worn, and often so clean that it would scarcely soil a handkerchief. Its interstices commonly contained a few gallons of water at the lower part, and some air or gas at the upper. The gas in many instances was inflammable, and was doubtless derived from the numerous boulders of highly bituminous limestone found in the clay. That the pockets were perfectly isolated is shown by the fact that though nearly eighty feet beneath the surface of the lake, they scarcely leaked a drop of water after they were once emptied. The existence of these masses of gravel is very surprising. The cavities, when emptied, looked exactly in many instances like the casts of rounded boulders. I can only account for them by the theory that they were deposited as frozen masses of gravel, and thawed after they were well imbedded in the clay, leaving their strata in whatever position they happened to be put while frozen.

After getting beneath the deposits made by the lake itself, the excavations furnished not the slightest traces of any organic remains.

Along the west shore of Lake Michigan, for a distance of over a hundred miles north of this place, the glacial drift rises some eighty feet above the water in precipitous bluffs. In many places the bluffs are eroded by the waves, and show fine sections. To one standing close by it is often extremely difficult to notice any stratification, but to an observer stationed in a boat a hundred yards distant, dim but evident traces of a horizontal arrangement appear. The strata are best seen by noting the level bands where the springs ooze out.

The more recent formation may frequently be noticed as a well stratified deposit filling the hollows or valleys of the older drift, and rising to nearly the same height above the lake. It perhaps belongs to the Champlain epoch. It is greatly to be desired that some geologist should thoroughly examine the recent geology around Lake Michigan, as there are problems of great interest to be solved in connection with it; but as yet it is an unexplored field.

Chicago, Nov. 26, 1866.

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Art. XII.—*Shooting Stars in November*, 1866; by H. A. Newton.

The brilliant exhibition of the November meteors witnessed in Europe on the 14th of that month is a confirmation (if such confirmation was needed) of the astronomical character of these bodies, and of the thirty-three-year cycle. The European observations are evidently those which will throw most light upon their cosmical relations. Yet those made in this country on the nights of Nov. 12th–13th and 13th–14th must have decided value. The radiant point in Leo rises above our horizon about 11 o'clock P. M., which corresponds with 4^h A. M. Greenwich time. Our observations then from midnight onward on the morning of the 14th may be regarded as a continuation of those which in England were interrupted by the approach of daylight. They serve to give the law of decrease in density of the meteoroids as we leave the group. On the other hand, during the former night the earth was approaching the group, being at dawn only fifteen hours distant from its center.

1. *At New Haven.*—On the two nights 10th–12th of November the sky was entirely overcast; so also on the nights 14th–16th. On the night of Nov. 12th–13th we commenced counting the shooting stars ten minutes after 11 o'clock. There were fifteen or more in the party, principally students in the College. It was intended that at least twelve persons should be continually looking for the meteors. This number was maintained throughout the watch on this and the following nights, except for a very short period when only eight or ten were present. During part of the time, on the first night particularly, there were, besides the twelve, from two to five others assisting in counting. Two of us gave our attention to the location of the paths of particular meteors, remarkable for size, color, trains, &c., and to other objects aside from the counting.

We watched from the top of the tower of Graduates' Hall, from which there is an unobstructed view of the heavens. To nine persons were assigned particular portions of the sky around the horizon, and three looked toward the zenith. The meteors were counted aloud to prevent duplication. The total number seen by the party in each quarter-hour was thus obtained. It was also important to learn how many meteors each observer saw. To prevent the confusion that would result from counting in a double series, I gave to each person a card with directions to keep a tally upon it of those seen by himself. A few of these tallies were afterwards found to be imperfect, but the residue enable us to compare our numbers with those seen elsewhere by fewer observers.

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The first party continued the watch until $1^h\ 40^m$ A. M., counting in these two and a half hours 236 meteors, as follows:

Time.			Duration.	No. seen.	No. per hour.
$11^h\ 10^m$	to	$11^h\ 30^m$	20^m	37	
30	"	45	15	27	
45	"	12 0	15	26	108
12 0	"	15	15	22	
15	"	30	15	17	
30	"	45	15	21	
45	"	1 0	15	21	81
1 0	"	15	15	25	
15	"	30	15	20	
30	"	40	10	20	97
		Total in $2^h\ 30^m$		236	94 hourly av.

The meteors were generally small and very few of them were from Leo. Few left trains. During these 2½ hours nine of the party saw severally 34, 10, 41, 26, 40, 62, 22, 62 and 68. This gives an average of 40½ to each observer, or 16 per hour. The proportion of the mean for single observers to the whole number seen is 17 per cent.

The large variation in the numbers seen (from 10 to 68) is due to a variety of causes. The three who looked to the zenith saw much the larger numbers. Some of the others may have looked too low down in the horizon, or there may have been a slight haze in the direction toward which they were looking. Besides all this, there is undoubtedly a personal difference depending on closeness of attention and sharpness of eyes.

At $2^h\ 40^m$, after an interval of one hour, a new party began to count, and the following was the result:

Time.			Duration.	No. seen.	Hourly No.
From $2^h\ 40^m$	to	$2^h\ 45^m$	in 5^m	15	
45	"	3 0	15	44	177
3 0	"	15	15	38	
15	"	30	15	37	
30	"	45	15	38	
45	"	4 0	15	27	140
4 0	"	15	15	38	
15	"	30	15	44	
30	"	45	15	43	
45	"	5 0	15	44	169
5 0	"	15	15	54	
15	"	30	15	36	180
		Total in $2^h\ 50^m$		458	162 hourly av.

The following are the reports of the numbers seen by individual observers. Those looking the whole time saw 56, 41, 100, and 55; one from 3^h onwards saw 26, one from $3^h\ 15^m$ saw 49,

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one ending at $4^h\ 10^m$ saw 32, and one ending at $4^h\ 30^m$ saw 23. This gives an average hourly number of about 19½ for each observer, which is 12 per cent of all seen.

By 3^h A. M. the proportion of conformable meteors had considerably increased, so that they were then estimated to be at least one-fourth of the whole number visible. At 5 o'clock the proportion, though greater, was still less than one-half. During the quarter-hour $5^h\ 15^m$–$5^h\ 30^m$ the increasing light of the dawn in the east was interfering very considerably with the numbers visible.

The sky was beautifully clear throughout the night. The center of the radiant of the conformable flights seemed to be about R. A. 147° 30′, Dec. +23° 15′. It was not very easy to determine its shape and dimensions owing to the small number of flights near the radiant. The zodiacal light was remarkably fine in the east.

On the night of Nov. 13th–14th a new relay of observers began to count at 11 o'clock. They were relieved by a fourth party about 2 o'clock A. M. The arrangements were similar to those of the previous night. The following are the results for the successive quarter hours.

11h–12h.	12h–1h.	1h–2h.	2h–3h.	3h–4h.
22	37	47	33	65
29	43	37	36	36
35	56	50	55	56
36	61	37	55	55
122	197	171	179	212

At 4 o'clock it was decided to break up. A desultory counting gave 20 during the next ten minutes, or 901 in all. Between $1^h\ 15^m$ and $2^h\ 30^m$ the number of observers was not quite as large as usual, and the attention was somewhat broken by the changing of the party. Throughout this time and the hour following the clouds interfered to an appreciable extent.

A considerable portion of the meteors were much more brilliant than those of the previous night; also a much larger proportion proceeded from the Leo radiant. These were brighter than the others. At a quarter past twelve o'clock it was estimated that about three-fifths of all were conformable. During the next hour there was an evident increase in this ratio.

During the first three hours four persons saw severally 116, 98, 82, and 96; one saw in 3½ hours 99. This gives a mean of 32 per hour for each observer, which is 20 per cent of the number seen by the whole party. From half past two o'clock onward the mean hourly number for one person, as deduced from the reports of ten of the party, was about 38, that is, about 18 per cent of the whole.

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If we compare the observations of the two nights, we see that the greater brilliancy of the meteors on the second night made the proportion seen by single observers to be greater. At the same time there was a much greater uniformity in the tallies reported. This is reasonable, for when the meteors are faint we may rightly expect a large *personal equation*. The average number of observers for the two nights was probably about fourteen. The mean of the proportions seen by single observers for the two portions of the two nights was about 17 per cent. Hence we may say that with such observers, such meteors, and such modes of observing, as we had on these two nights, fourteen persons will see about six times as many as one person. I think it probable that even so large a party loses a third, or more than a third, of the meteors that could be seen by an indefinite number of observers, especially when the flights are in general faint.

While the general position of the radiant on the second night would seem to be the same as that given on the first night, some stars moved from points nearer γ Leonis. Several paths produced backward would cut the line joining γ and ϵ Leonis within two or three degrees of the former star. I saw, however, no path that could not be referred to a radiant area of narrow breadth in latitude. In longitude its length would have to be three or four degrees, unless we admit, as Prof. Twining supposes, that there is a motion of the radiant. Prof. Hewitt of Olivet, Mich., gives a number of paths for the first night that seem to proceed from a point nearer γ than ϵ.

2. *At New Haven.*—Upon the roof of Sheffield Hall a party of about ten students, under the direction of Prof. Lyman, counted 603 meteors in five hours, from 12 o'clock onward, on the morning of the 13th of November. The following is the result of their observations for the successive quarter hours.

12h–1h.	1h–2h.	2h–3h.	3h–4h.	4h–5h.
24	25	38	43	27
21	31	22	39	38
17	..	30	35	34
21	47 for $\frac{1}{2}$h	39	38	34
83	103	129	155	133

On the next night a similar party in the same place counted 492 meteors between eleven and two o'clock, omitting the quarter hour between $11^h\ 15^m$ and $11^h\ 30^m$. This is a mean of 179 per hour. The following table gives the results.

	11h–12h.	12h–1h.	1h–2h.
	19	48	42
	..	48	53
	31	56	52
	38	50	55
Hourly mean	117	202	202

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These results agree as well perhaps as could be expected with those of the party on Graduates' Hall. A considerable number of paths were drawn upon the charts upon both evenings which will serve to determine the altitude, lengths, &c., of the trajectories, if the same have been observed elsewhere.

3. *At New Haven.*—Prof. Twining watched alone on the morning of Nov. 14th, giving special attention to the lengths of the paths, the duration of the flights, and the position and size of the radiant area. He says: "from midnight to 1^h A.M., looking toward Leo, I observed 35 shooting stars, in one hour, and in an area of about 110° of arc laterally, and 70° vertically. Of these there were 24 conformable from an area of radiation about 8° in diameter, whose center was in N.P.D. 65½° and A.R. 147½°. Two-thirds of all were directed nearly from this center. The sky was very clear. The conformable meteors were rather massive, with tracks about 1′ broad. Three were much broader, and left trains for 2^s to 6^s of time. The two longest flights that I observed were 20° and 22° of arc and about 1^s in time.

"Again I watched from 3^h 8^m A.M. to 4^h 8^m A.M., or one hour. In a space equal to the former and looking toward the radiant I saw 43 meteors, of which 38 were conformable to an area covering nearly the bend of the Sickle,—but far the greater number radiating closely from the small star in its middle, being the old radiant of Nov. 13th, 1833. The flights were generally from 5° to 15° long, and the longest 22° in $\cdot 7^s$ of time. The average of the 62 conformable flights, for the two hours, was about 10° of arc, in $\cdot 5^s$ of time. But the flights of the earlier hour were shorter than those of the later, while the times were longer. It is of course true that the velocity of meteors *must be retarded by the gaseous medium* in which their visible paths are developed. The force of this medium, condensed before their masses, is so great that, not unfrequently, a curve, or even an angle is described in a meteor's path. These sudden deviations—as well as the frequent explosions—may often be due to the meteor's passage from the *secondary atmosphere of the earth* (allowing this really to exist, as I have formerly suggested, and being composed, perhaps, of aqueous vapor) into its atmosphere proper.*

"Better means of determining the radiant—or rather the lines of flight—than the unaided eye affords are now necessary. The best I have thought of would be a conical shell mounted upon a pillar and rotated by clock work, like a telescope. The cone should have its axis directed to the presumed radiant,—its opposite elements spreading, say 90°,—its apex truncated to an opening but little greater in circle than the pupil of the eye, and its larger circle, or base, traversed by wires divergent from its center, at equal intervals, and these last supporting and normally

* This Journal, [2], xxvii, 20.

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cut by a system of circular wires showing equal intervals of arc when viewed from the apex,—the whole combination appearing to the observer like the meridian lines and circles of polar distance in a stereographic polar projection. The open base may be slightly illuminated if the wires are not sufficiently visible against the sky.

"With this apparatus adjusted to a proper position of the axis, it is obvious that conformable meteors will traverse lines, along or between the divergent wires; and that the inclinations to the wires can be closely estimated, as well as the distances from the center at which the prolonged paths would pass. At the same time the parallel circles would, if properly disposed and designated, afford a scale to mark the beginning and the end of flights with the best attainable accuracy. The intersection of selected standard stars by the wires might be agreed upon, in common, to fix a position for the axes of the shells, in all places where they should be employed for comparative observations, although, if the axial position were ascertained in each case, that uniformity would not be indispensable."

4. *At Philadelphia.*—On the morning of the 13th Mr. B. V. Marsh saw in a half hour ending at $1^h\ 40^m$, 2 conformable meteors and 6 others; in a half hour ending at $4^h\ 36^m$, 5 conf. and 3 others. The weather was clear and bright. The number for the hour (16) corresponds with the number (18) for single observers on that night at New Haven. On the next morning Mr. Marsh saw in 36 minutes, between 12^h and 1^h, 23 conf. and 5 unconf. meteors. Later in the morning the sky was mostly overcast.

5. *At Newark, N. J.*—Mr. C. G. Rockwood, on the night of Nov. 12th–13th, watched from $10^h\ 45^m$ to $2^h\ 30^m$ A. M., omitting the quarter hour from $12^h\ 45^m$ to 1^h. The sky was clear except a haze near the horizon. The following table gives the results.

	Conf.	Nonconf.	Total.
From $10^h\ 45^m$ to $11^h\ 0^m$,	0	5	5
" 11 3 " 12 0,	2	23	25
" 12 0 " 12 45,	6	5	11
" 1 0 " 2 0,	16	15	31
" 2 0 " 2 30,	5	8	13
Total in $3^h\ 27^m$,	29	56	85

On the next night, with four assistants, he watched from $11^h\ 20^m$ to $2^h\ 40^m$, counting 261 meteors, as follows:

Time.	Conf.	Nonconf.	Total.	Duration.
$11^h\ 20^m$–$12^h\ 0^m$	13	43	56	in 40^m
12 0 –12 30	27	29	56	30
12 30 – 1 0	33	24	57	30
1 30 – 2 0	40	15	55	30
2 0 – 2 30	20	14	34	30
2 30 – 2 40	2	1	3	10
Total,	135	126	261	in $2^h\ 50^m$

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For a good part of the time it was cloudy in the south and southwest and also low down in the northeast. After 2^h A. M. the clouds increased rapidly and soon covered the sky.

6. *At Poughkeepsie, N. Y.*—Seven of the pupils of Miss Maria Mitchell saw, at the Vassar College Observatory, 354 meteors in seven hours on the night of Nov. 12th–13th, and on the next night 419 were seen by six of them in five hours.

7. *At Canonsburg, Pa.*—Prof. Kirkwood reports 64 seen by six persons in 45 minutes, ending at 4^h 39^m A. M. of the 13th, of which about 50 were from Leo. The next night was cloudy.

8. *At Franklin, N. Y.*—Mr. William A. Anthony, with two assistants, counted on the morning of the 14th, between 2^h and 4^h, 180. On account of the cold it was impossible to stand still and watch the heavens, and one hour, or an hour and a quarter at most, would, he thinks, include the time they were watching.

9. *At Cambridge, Mass.*—Mr. F. W. Russell watched during several evenings in the first half of November. He has plotted 60 or 70 flights, which were remarkable for size or beauty, and reports 875 in all. The details have not yet been received.

10. *At Chicago, Ill.*—Mr. Francis Bradley reports 27 meteors seen by three persons in one hour ending at 2^h 30^m on the morning of Nov. 12th. On the next night five observers saw in the hour and a half ending at 1^h A. M., 65 meteors, of which 24 were from Leo. Clouds or haze prevented further observation.

11. *At Olivet, Mich.*—Prof. J. H. Hewitt, to whom on account of his previous experience in observing I had written requesting particular attention to the shape of the radiant area, watched on the night of Nov. 12th–13th, together with Mr. M. R. Gaines, from 11 to 5 o'clock. The night was mostly clear. He says: "of those which went from the Sickle, the tracks of the larger number, I think, were in the general direction of a line joining γ and ϵ, and these tracks were much nearer together than the tracks of those which proceeded in a direction perpendicular to that line. That is, supposing an ellipse to represent the radiant area, the larger diameter would be in the direction of $\gamma\epsilon$. We frequently remarked that our observations coincided with your suspicions that the radiant area would be such an ellipse."

12. *At Detroit, Mich.*—Mr. O. B. Wheeler reports 56 for three observers for one hour from 2^h 20^m A. M. Nov. 13th. Forty-two were conformable. Clouds prevented observation on other nights.

13. Mr. Charles G. Boerner of Vevay, Ind., sends a chart upon which he has recorded the paths of meteors observed on the mornings of the 12th and the 13th. The next night was cloudy.

14. *At Iowa City, Iowa.*—A party of students of the Iowa State University, under the direction of Prof. Hinrichs, watched through the nights of Nov. 12th and Nov. 13th. During the first of these two nights the sky was mostly clouded except from

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about one to three o'clock A.M., where it was pretty clear overhead. Thirty-five meteors were seen, of which twenty-two were in the hours named. Three persons were observing.

On the next night, Nov. 13th–14th, it was partially overcast until near 10 o'clock. The number seen was 440. The hourly number, the number of observers, and the state of the sky, are given in the following table.

Time.	No. obs.	No. seen.	Sky.	Time.	No. obs.	No. seen.	Sky.
$8\frac{1}{2}^h$– $9\frac{1}{2}^h$	3	4	Cloudy.	$12\frac{1}{2}^h$–$1\frac{1}{2}^h$	4	90	Clear.
$9\frac{1}{2}$ –$10\frac{1}{2}$	3	8	Partly clear.	$1\frac{1}{2}$ –$2\frac{1}{2}$	5	112	Clear.
$10\frac{1}{2}$ –$11\frac{1}{2}$	3	7	Some clouds.	$2\frac{1}{2}$ –$3\frac{1}{2}$	5	138	Clear.
$11\frac{1}{2}$ –$12\frac{1}{2}$	4	61	Clear.	$3\frac{1}{2}$ –$4\frac{1}{2}$	5	20	Clouding.

Soon after $3\frac{1}{2}^h$ A.M. the sky became wholly overcast. The next night the sky was also entirely covered.

15. *At Washington, D. C.*—Observations were made at the U. S. Naval Observatory which will soon be published in full.

16. *In Bay of Panama.*—Mr. Frank H. Bradley writes to Prof. Twining, that with about a quarter of the sky clear he counted eleven meteors between 1^h 45^m and 2^h 30^m A.M. on the morning of Nov. 13th. The sky then became overcast.

On the next morning he was on deck from 2^h to 3^h A.M., and in that time counted 30 meteors, 17 of which seemed to be radiant from a point near the horizon in the N.N.E. The sky was clear from N.E. to N.W. and a little past the zenith, but about 3^h A.M. the clouds closed entirely.

On the night of the 14th–15th he was on deck for some time, with much clear sky, but saw no meteors.

17. I am indebted to Prof. Henry, who has kindly placed in my hands for examination the reports received by the Smithsonian Institution from various observers.

Prof. Hopkins of Williams College gives the times of 205 meteors on the night of the 12th–13th, of 453 on the next night, and 4 on the third night. The apparent paths of a large proportion of them is also given. The following are the numbers for the successive hours.

Time.	12th–13th.	13th–14th.	Time.	12th–13th.	13th–14th.
Before 7^h	1	6	12^h–1^h	2	51
7^h– 8	2	9	1 –2	10	71
8 – 9	0	19	2 –3	45	53
9 –10	7	16	3 –4	40	61
10 –11	10	21	4 –5	41	69
11 –12	23	33	5 –6	24	44

Between 11^h 30^m P.M. and 2^h 15^m A.M. of the first night the clouds interfered seriously, and sometimes even covered the sky. This series of observations will no doubt prove to be of special value for the computation of altitudes.

The reports received by the Smithsonian Institution from a large number of other observers will be of value for the same purpose.

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18. Two meteors deserve special notice. One at $11^h\ 7^m$, Nov. 13th, appeared at New Haven low in the Lynx, and passing a little north of the zenith, crossed Andromeda between α and β, and disappeared low in the S.W. having described a path of 135°. I was at first a bright point, but after a time burst out into a flame and left a train for several seconds. The duration of flight was called four seconds. At Newark and Philadelphia the same star described a similar long arc. At Williamstown it appeared 5° from Mars towards Canis Minor, and ended ½° S. of Diphda; duration 7 seconds. These data give the first altitude 88 miles (142 kilometers), the least altitude 66 miles (106 km.), and the length of the path, according to the Williamstown observation, 325 miles. It must have passed beyond Diphda, however, as seen from that place, since it disappeared in the S.W. at Philadelphia. Seven seconds for 325 miles gives 46 miles per second for the velocity, a result probably too great.

19. At 11 minutes past 2 o'clock A.M., Nov. 14th, a very bright green (or blue) meteor appeared, at New Haven, in R.A. 148°, Dec. +16½°, and went to R.A. 143½°, Dec. +9°, leaving a train about 4° long. This train floated away 8° to the north in a path parallel to the horizon, being visible for 9 minutes. Before disappearance it had become shorter and broader so as to be 2° or 3° long and 1½° broad.

The same meteor was seen in Newark by Mr. C. G. Rockwood to descend vertically, ending at R.A. 163°, Dec. +15½°. The cloud or train floated also northward, parallel to the horizon, crossing δ Leonis. A corresponding path is given by Mr. Henry M. Parkhurst of Brooklyn.

At Williamstown the record was "origin 20° south of Regulus: course W.S.W.; length 40°; blue trail."

The first altitude was then about 120 miles (193 km.), the altitude at disappearance about 60 miles (97 km.), and the length of path 115 miles.

The cloud as seen from Newark bent up as is usual with such trains, while at New Haven it only grew shorter and broader, a result doubtless of perspective. The meteor's distance from New Haven at disappearance was 120 miles, and the cloud was doubtless still farther from us. Hence its length must have been more than 5 miles and its breadth over 3 miles. The true motion of the cloud was northward, at right angles to the motion of the meteor, being in nine minutes at least 17 miles, and probably about 20. It was evidently due to a current in the atmosphere, whose velocity was about 125 miles per hour.

The material of the meteor must have been considerable in order to have filled several cubic miles with its debris. And yet this debris must have been very attenuated to float in an atmosphere so light as that which is 60 or 90 miles from the earth's surface.

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20. The great display which was looked for with such general interest both in this country and in England was witnessed in Europe early on the morning of the 14th.

At Valentia, Ireland.—The following is an extract from a letter from Dr. B. A. Gould, who was at Valentia, Ireland, engaged in determining the longitude of American stations by means of the Atlantic cable.

"At $12^h\ 30^m$ (Greenwich time) meteors were so abundant that I caused the telegraphic staff to be aroused, in confident expectation of a 'meteoric shower.' From this time to about $2^h\ 25^m$ A.M. the sky was quite clear (except for six or seven minutes), not more than one-fourth part being at any one time obscured. At 1^h A.M. the sky was brilliant with meteors of every degree of brightness, from the 4th magnitude to 15′ diameter, and the brilliancy of Jupiter. The largest ones, and certainly there were fifteen or twenty such, were as brilliant and large as a ship's rocket at half a mile distance.

"The comparatively slow and uniform movement of most of them, their long bright trains, and pure white light, presented a strong resemblance to a flight of rockets.

"The center of divergence was in Leo, then not high in the east. The radiant was not well defined, but a locus of probably a degree and a half in diameter. I think that I observed ten or twelve of which the paths produced would form tangents to such a circle.* During the whole display I saw but two unconformable meteors, both of them faint. * *

"Between $12^h\ 39^m\ 0^s$ and $1^h\ 5^m\ 0^s$ I counted 310. * * * With the aid of a friend, who faced south while I faced north, I counted 203 during the 90 seconds between $1^h\ 9^m\ 0^s$ and $1^h\ 10^m\ 30^s$. Ten minutes later the frequency seemed to have much diminished.

"At $1^h\ 38^m$ there were not more than 65 or 70 to the minute, and frequently five or six seconds would pass without any being seen.

"Between $1^h\ 45^m\ 15^s$ and $1^h\ 46^m\ 15^s$ (1^m) only 23 were seen.

"	1	49	0	"	1	51	0	(2^m)	"	22	"
"	1	58	0	"	2	1	0	(3^m)	"	17	"

"At $2^h\ 15^m$ they seemed scarcely more numerous than on an ordinary August night."

21. *In Exeter, England.*—Mr. J. T. Tucker, of Exeter, in a letter to the writer states that he counted 954 meteors between $12^h\ 30^m$ and $1^h\ 30^m$ A.M. of Nov. 14th.

22. *At Manchester, England.*—Mr. Joseph Baxendell, F.R.A.S., devoted special attention to the place of the radiant, and the time of the maximum. He gives for the former, R.A. 149° 33′, Dec. +22° 57′·5, which is the mean of a number of observations. For the time of maximum frequency he gives $1^h\ 12^m$ A.M. (Gr. time), and thinks that the probable error cannot exceed one minute. He saw the shower of 1833, being then at sea off the west coast of Central America, and says that the present display

* A diagram gives the center of this circle as about R.A. 148°, Dec. +23½°.

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was far inferior to the former, both in the number of meteors seen and in the brilliancy of the larger ones.*

23. *At Greenwich.*—According to an extract from the *London Herald*, the hourly numbers seen at the Greenwich observatory were as follows:

9^h–10^h	10	meteors,	12^h–1^h	2032	meteors,	3^h–4^h	528	meteors.
10 –11	15	"	1 –2	4860	"	4 –5	40	"
11 –12	168	"	2 –3	832	"	Total,	8485	"

24. *Thickness of the group.*—The inclination of the plane of the group to the ecliptic is probably about twice the latitude of the radiant, or 19°. The denser part of the shower was included in a period of about $1^h\ 30^m$; and during this time the earth moved about 100,000 miles. The corresponding thickness of the group would be 100,000 sin 19°, or 33,000 miles. The density gradually diminishes as we leave the center of the group, and the thickness, including these rarer portions would be much greater.

25. *Geographical limits of the shower.*—The sun was vertical at $12^h\ 30^m$ A.M. (Gr. time) in E. lon. 168½°, S. lat. 18¼°. If this time be taken for the beginning of the shower as a great display, and if 10° be allowed for twilight, a line crossing the equator in E. lon. 68½° and running N. 18¼° E. separated daylight from darkness and forms the eastern limit beyond which the shower was not probably visible.

The radiant was vertical at 2^h A.M. (which may be taken for the end of the shower) in N. lat. 23½°, E. lon. 65°. The western limit would be a great circle of which that point is a pole, to wit, a line crossing the equator in W. lon. 25°, and running N. 23½° W. This line passes from Newfoundland through the center of the two Atlantic oceans. Regions west of this line were behind the earth throughout the shower. Along this line a few meteors with long paths were probably visible.

26. If there shall be a shower in Nov. 1867 (and it is quite probable that there will be one), and if the group lies sensibly in a plane, these limiting lines would be removed 90° or 100° westward. But what curves in the line of the group have been produced by the perturbing action of the earth, of Jupiter, and of the other planets we cannot say. Such curves apparently exist, and may change the time of maximum, and therefore the region in which the shower may be expected next November.

When full and authentic reports from English astronomers shall be received I hope to resume the subject.

* Proc. Man. Lit. and Phil. Soc., vi, 31.

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ART. XIII.—*Correspondence of Prof.* JEROME NICKLÈS, *dated Nancy, October 2d,* 1866.

Obituary: Hermann Goldschmidt, the Astronomer.—The subject of this notice attained to a considerable reputation as an artist, but he is better known to the scientific world, in which he held a high position, by his numerous discoveries among the heavenly bodies.

He was born June 17th, 1802, but during his whole life his health was delicate. Destined at first to commerce, he quitted it to devote himself to painting, and early became distinguished in that career. He was, however, ignorant of his true vocation until he had attained the age of forty-five years. One of his friends, Dr. Hoefer, to whom we are indebted for these details, tells us the circumstances under which he became an astronomer. The recital is copied from Goldschmidt himself. "I had just returned," says he, "full of disgust from a very long sojourn in England. I tried in innumerable ways to dissipate my melancholy humor, but without success, when one day I chanced to attend LeVerrier's lecture on astronomy. The professor explained an eclipse of the moon which was to take place the same evening (March 31st, 1847). I understood the explanation, and in my enthusiasm I exclaimed *anch' io son.* From that moment I commenced with ardor to study a science of which I had as yet only the feeblest notions."

Three years after, Nov. 15th, 1852, Goldschmidt discovered, with a small glass which he had just bought, a planet which received from Arago the name of *Lutetia*, having the brightness of a star of the 10th magnitude. The 26th of October he discovered *Pomone*, which resembled a star of the 11th magnitude. He afterward successively discovered the following: *Atalante*, Oct. 5th, 1855; *Harmonia*, March 31st, 1856; *Daphne*, May 22d, 1856; *Nysa*, May 27th, 1857; *Eugénia*, July 11th, 1857; *Melete*, Sept. 9th, 1857; *Palés*, Sept. 19th, 1857; *Doris*, id.; *Europa*, Feb. 6th, 1858; *Alexandra*, Sept. 10th, 1858; *Danae*, Sept. 19th, 1860; *Canope*, May 9th, 1861. By reason of these discoveries he several times received the astronomical prize from the Academy of Sciences. He also determined the position of more than ten thousand stars which before had no place upon any known map of the heavens—and it was among these stars that he found the planets previously enumerated.

He made these discoveries with a small glass—and his observatory was situated in one of the most frequented streets of Paris. Not favored by fortune, Goldschmidt lived on a pension paid him by the French government. For a long time he had been troubled with his eyes, but this affliction affected him much less

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than diabetes, the symptoms of which he first felt in 1854. He then retired to the country, and for three years lived at Fontainbleau, dividing his time between painting and astronomy. Toward the latter part of last August his disease became complicated with other difficulties. He hastily finished his papers upon the physical constitution of the sun, and died on the 20th of August. He leaves a widow and two daughters without fortune. They will doubtless be adopted by the "Société de Secours Amis des Sciences."

Spectrum of aqueous vapor.—We now know the nature of the rays which Brewster discovered in 1833, and which have since been termed telluric or atmospheric. M. Janssen has made several investigations under the patronage of the Minister of Public Instruction, and has found that these rays are occasioned by the vapor of water. By means of new optical dispositions he has proved that the bands of Brewster were formed of fine lines, like the lines of Fraunhofer, and that they were constant in the spectrum, though of variable intensity according to the height of the sun. Relying upon this character of the telluric rays he has made a chart of the spectrum in which the distinction between the solar and telluric rays is clearly shown.

Janssen has also made numerous other experiments. In September, 1864, from the summit of the Faulhorn, he observed the rays of terrestrial origin and found they became weak in proportion as they were elevated and as the light had less thickness of atmosphere to traverse. In the same year he made an experiment upon Lake Geneva, and by reason of the humid air of the lake he was able to reproduce the same rays artificially. The flame from a large pile of pine wood at the distance of 21 kilometers presented these lines, but when viewed at a less distance no ray was visible except the brilliant one of sodium. Janssen stationed himself on the side of the lake opposite the fire, so that the light from the blazing pile, which was on a level with the surface of the water, might penetrate strata of air saturated with moisture.

It was necessary to ascertain if these effects were caused by the water in solution in the atmosphere, or whether, as Mr. Secchi thought, they were to be attributed to the vesicles of which mist and fogs are composed. A direct experiment confirmed him in the opinion that they were produced by the vapor. Janssen operated with a tube thirty-seven meters in length, which was filled with vapor by a steam engine of six horse-power. Care was taken to prevent the tube from cooling, and the light was furnished by a flame of gas placed in the axis of the tube. When the light passes through the tube filled with vapor subjected to the pressure of seven atmospheres it shows the principal telluric rays, among which Janssen places the

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groups A and C and a large part of B, contrary to Kirchhoff, who attributes A and B to potassium. The red and yellow of the spectrum of water-vapor are more brilliant than the blue and violet. Therefore the color of the vapor of water should be orange; hence, also, the red of the setting sun, that is, of the sun seen near the horizon. Janssen does not agree upon this point with the conclusions of Prof. Cooke, which were published in this Journal for March, 1866. According to the latter the vapor of water absorbs most completely the yellow and the red rays, hence the blue rays predominate in the spectrum that is transmitted. Prof. Cooke has, however, discovered and demonstrated by his own researches (this Journal, [2], xli, 184, also Journal de Pharmacie et de Chemie, June, 1866, p. 480), the influence of the vapor of water upon the phenomenon in question.

A new property of magnesium.—One evening while preparing some perchlorid of manganese, $MnCl^2$ (this Journal, [2], xli, 107), with the peroxyd of manganese, the chlorhydric acid of commerce and ether, I observed that the color was not green, as it appeared to be in the daytime, but *black*. I was using gas for a light, and substituted in place of it first an oil lamp and afterward a wax candle, but the effect was the same, the color still appeared only black.

The *green* color reappeared by the flame of magnesium, which comports itself in this respect like the light of the sun. It is well known that bright-tinted flowers, colored stuffs, or pictures, exhibit much less brilliancy of coloring by wax or even gas light than when seen by the light of day, and should an artist, at the close of the day, wishing to supply the waning light, continue his work by the aid of wax lights or gas, he would be surprised the next morning at the assemblage of colors he had made the evening previous. They would in no way represent his thought, so different would they appear when viewed in the two lights.

By burning a thread of magnesium a light may be obtained which will make these colors appear the same as when seen by sunlight itself. Colors do not mingle or interchange by this light as they do by ordinary lights. Green does not appear to be blue in it, neither does blue have the slightest appearance of green. In short, all shades preserve the same appearance as when viewed in the full light of day. The flame of magnesium is whiter than solar light, and the blue predominates in it. Chemistry aids the painter not merely by furnishing colors more or less bright, but it now gives him a new mode of illumination by means of which he can labor at night without fear of optical deception, as well as if it were daylight.

The influence of sodium upon flame.—On inquiring the reason for the extinction of color by the usual flame, which we have

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just been discussing, it will be found that numerous causes produce this effect, one of which is *sodium*, which burns with a *yellow* (monochromatic) flame, that may be obtained either by bringing common salt supported on platinum wire into the flame of the Bunsen lamp, or by burning alcohol saturated with salt. All the colors are altered by this flame, with the exception of blue-violet, which is complementary to the yellow. Red appears black or white, sometimes bluish when it contains blue (see below, *physiological effects*). Mixed green appears *yellowish* or bluish (chlorophyl Schweinfurth green). The pure greens appear black (ex. $MnCl^2$, $MnBr^2$, MnI^2 combined with ether, $BaOMnO^3$, Cr^2O^3, gold leaf seen by transmitted light, Cr^2Cl^3, &c.). Vide Annales de Chem. et de Phys., [4], viii, 298, for the enumeration of the various colors which have been experimented with.

The following table gives the result of some trials which I have made with a spectrum prepared by applying pigments to white paper. We give the composition of the spectrum and the colors with which it was obtained.

Colors seen by daylight.	Coloring material.	Colors seen by a monochromatic flame.
Red.	Ochre (Fe^2O^3), - - -	Black.
Orange.	Iodid of mercury (HgI),	White.
Yellow.	Chromate of lead ($PbOCrO^3$).	
Green.	Manganate of baryta, - -	Black.
Blue.	Aniline blue,	

In this spectrum so wonderfully changed by the flame of alcohol saturated with salt, sunlight and the flame from magnesium instantly restored the normal colors, even while the sodium flame was burning in the neighborhood. They also reappeared by gaslight, but with much less intensity, and when the colors are not very brilliant they are modified as if they were illuminated by the soda flame.

Thus etherial solution of perchlorid of manganese when impure appears by gas light *black* instead of *green*. A mixed green composed of chromate of lead ($PbOCrO^3$) and ultramarine behaves in the same manner.

If the illuminating flame were saturated with sodium its extinctive effects would be still more energetic, ordinary flames containing but very little of this metal. Spectral analysis shows us that instead of completely extinguishing colors it merely alters them a degree more or less, darkening some and enlivening others, and creating confusion between blue and green.

The small quantities of sodium which all ordinary flames contain, are derived from several sources, viz., the mineral matters of wicks of lamps and candles, ashes of fuel and atmospheric air, which last, according to Bunsen, always contains traces of it.

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Vogel has determined the proportion of soda which illuminating gas contains (Journ. de Pharm. et de Chem., October, 1866), and Mulder has shown (in the same Journal, May, 1866), with what facility marine salt volatilizes when heated with coal.

Small as the quantity of sodium is which illuminating gas contains, it is sufficient to affect certain colors, and to produce on a small scale all the effects of absorption or extinction which are readily seen in a flame saturated with it. Examples of this may be seen in certain green colors mentioned above.

Physiological effects of the monochromatic flame.—The foregoing results explain a well known phenomenon, which has hitherto never been accounted for. In the flame of alcohol and salt, the hands and face appear of a *livid green* hue, while the lips change to a *blue-violet*. This livid tint is known to all who have seen punch or a pudding burn, and is due to the alcohol more or less saline which is employed in these mixtures. Workmen at furnaces and forges are familiar with these peculiar tints, which appear upon the features illuminated by their fires.

In the first case the effect is produced by the NaCl which the alcohol contains of itself or which it derives from the alimentary substances; in the latter case the soda is obtained from the dross, and ashes of the combustible matters. The question arises, why under these conditions, the natural flesh color is changed to a *bluish* or livid green. The reply is evident. It has been shown above, that the colors which best resist the extinctive effects of the soda flame are those which come from blue.

That there is blue in human blood may easily be seen by the color in daylight of the large veins on the skin of the hand. All the other tints which enter into the composition of flesh color being extinguished except the blue, that shade alone remains upon the face of the experimenter, but being also illumined by a yellow flame, it is plain that the effects of the two colors will be to produce a *green*, varying in shade from yellowish to bluish according to the intensity of the blue, and producing a most sinister aspect on the human countenance. The eye speedily accommodates itself to these effects, but I have good reason for thinking that one cannot with safety, continue to work for any great length of time by this monotonous light. The retina after a time becomes so much affected as not to be able to bear without irritation either daylight or the ordinary illumination used at night, a result possibly caused by the absence of chemical rays in the flame, or because it injures the optic nerve which is poorly adapted to such a medium.

After sitting for a considerable time in the soda light, there comes a time when it is difficult to distinguish between the different shades of the same color. I have many times seen a tuft of leaves appear of the identical shade of the hand which held it, so

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that the whole had the effect of a bronze, while at the beginning of the experiment before the eye had become fatigued, it was easy to distinguish between the violet of the chlorophyl and the livid green of the flesh color.

Employment of the Sodium flame by artists.—We have previously shown that the different colors of the spectrum may be reduced to white or black, unless they contain blue which is the only color unaffected by the soda flame.

In observing such a spectral image it will be noticed, that if all the colors are reduced to either white or black, the borders are more or less darkened or dulled as in a photograph of the spectrum. Looking at a painting, especially a pastel containing very little if any blue, under these conditions, one is struck with the fact, that although the colors vanish, the grayish tone which represents them gives the appearance of a pencil drawing. The model or plan exists by reason of the half tints so that by the monochromatic light, one is sometimes able to go back to the design without touching the picture and can thus give in some sort the autopsis of a work of art.

The flame of sodium may yet aid the painter in comparing shades, in grouping colors and weighing their tones.

In the same manner, two colors, for example two *greens* which appear identical upon the palette, in the daytime, may be different when seen by common evening light, and are more likely to differ when viewed by the sodium flame, one being decolorized and the other transformed into black. In the same manner, of two *reds* seen under the same conditions, one may appear white, while the other containing *blue*, will assume a *violet*-tint complementary to the yellow of the monochromatic flame.

Common salt ignited on a platinum wire in the flame of a Bunsen burner, strikingly exhibits the chemical differences which sometimes exist between two similar shades of color. This means may be useful in distinguishing original pictures from copies, for it is not likely that Raphael or Van Dyck, for instance, exployed exactly the same pigments as their copyists have used.

If one desire to render the flame of a gas burner or of an oil lamp monochromatic, it cannot be done with NaCl, for the flame is not hot enough to volatilize that compound. Metallic sodium should be used for this purpose, which may be introduced into the gas burner or held in the flame upon platinum wire.

Perchlorid of Lead, $PbCl^2$.—In connection with what we said last year (this Journal, [2], xli, 107 and 55) upon the halogen compounds corresponding to the peroxyds, we have since obtained the compound $PbCl^2$ corresponding to the peroxyd of lead PbO^2. Unstable in a free state, it may be preserved for a long time in presence of a solution of chlorid of calcium.

It is prepared by passing a current of chlorine into chlorid of

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lead held in suspension in a solution of CaCl of 40° Beaumé. The liquid becomes yellow and acquires very curious properties. Thrown into a small quantity of water, it gives a precipitate of PbCl—with excess of water a brown precipitate is formed of PbO^2. $PbCl^2+2HO+Aq=PbO^2+2ClH+Aq$.

In this case the hydrochloric acid does not react, because of the excess of water present, if there were less the result would be $PbO^2+2ClH=2HO+PbCl+Cl$.

The perchlorid of lead does not act upon the nitrate of bismuth, behaving in this respect differently from $TlCl^3$ (this Journal, [2], xli, 107). When heated it blackens cane sugar but not glucose, and hence may serve to distinguish between these two kinds of sugar.

Treated with anhydrous ether and syrupy phosphoric acid, the solution of perchlorid of lead thickens, and yellow oily drops appear, which are perchloro-plumbic ether. This ether readily dissolves gold, and as the metal is taken up chlorid of lead separates assuming the form of the gold employed. The perchloro-plombic ether readily decomposes; the products are protochlorid of lead and chlorinated ethers. The ease with which chlorine separates from it, is the cause of its solvent power on gold, in which respect it is like the bodies presently to be noticed.

New solvents for Gold.—The perchlorids dissolve gold readily when that metal is in the form of leaf, on account of the facility of their decomposition with liberation of chlorine. If ethereal solution of perchlorid of manganese be employed, the green color of the manganese compound grows lighter in proportion as the gold dissolves, for $MnCl^3$ is reduced to MnCl, and the reaction is complete, when the liquid has exchanged its green color for the yellow of the solution of gold, (it is the same with $MnBr^2$ and MnI^2).* On evaporating the liquid, a film of gold adheres to the vessel. The same solution added to $FeOSO^3$ yields the precipitate of gold so characteristic for its dichroism.

The sesquichlorids, and the sesquibromids which are easily reduced—for example, the compounds corresponding to Mn^2O^3, Ni^2O^3, Co^2O^3; also Fe^2Br^3 even in presence of a certain proportion of FeBr—dissolve gold; Fe^2I^3 is also a good solvent for gold especially in presence of ether. It is only necessary to add a small quantity of Fe^2O^3 to the ethereal solution of iodhydric acid, in order to dissolve the metal. This proves that iodine in the nascent state acts upon gold. For this reason gold is acted upon even by iodhydric acid *in presence of ether.* No action takes place when only water is present. It can no longer be said with truth, that free iodine does not act upon gold. I have found that gold may be dissolved by it in presence of water,

* This Journal, [2], xli, 107.

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when put into a close vessel and raised to a temperature of 50°. The action is more slow if ether is used in place of water. Exposure to strong sunlight will hasten the solution.

Some new facts concerning amalgamation.—In vol. xli, p. 225 of this Journal, Prof. Silliman has described some properties of the *magnetic amalgam*, composed of mercury and sodium. The following experiment readily shows the great difference between the action of mercury and that of sodium amalgam.

Take a square of glass, to which apply side by side two leaves of beaten gold. If a drop of ordinary mercury be placed on one of these leaves, it adheres without sensibly increasing in area. On the contrary a small drop of the amalgam spreads out with great rapidity, so that in a few seconds the mercury has covered a space many hundred times larger than that which the original drop occupied.

I showed in 1853 (in this Journal)* that the metals moistened by mercury are permeable to it; that proposition has been verified upon the metals since discovered or prepared, viz., *thallium*, *aluminium* and *magnesium*. Thallium is easily amalgamated, and becomes brittle by the penetration of mercury; on the contrary, magnesium and aluminium resist its action or are not wetted by it until recourse is had to electric action, such as is realized by the intervention of sodium or zinc.

It would be interesting to observe the deportment of *indium* toward mercury. If it were capable of being moistened it would form with it a brittle amalgam; on the other hand, if it were not moistened it would retain all its elasticity. I leave the question to those who are fortunate enough to possess this metal so rare, and so difficult to obtain in a metallic mass.†

Chemical synthesis.—M. Berthelot continues his beautiful researches in synthesis, and is at present occupied with the generation of hydrocarbons. Our readers know that he formerly obtained acetylene, C^4H^2, by the direct union of hydrogen and carbon (this Journal, 1862). Berthelot has lately shown that a whole series of hydrocarbons, polymeric with C^4H^2, may be derived from it as follows:

Acetylene,	$C^4\ H^2$	
Di-acetylene, - - - -	$C^8\ H^4$	$=2C^4H^2$
Tri-acetylene or benzine, -	$C^{12}H^6$	$=3C^4H^2$
Tetracetylene or styrolene, -	$C^{16}H^8$	$=4C^4H^2$
..... - -	.....	
Retene, - - - -	$C^{36}H^{18}$	$=9C^4H^2$

This table is the result of actual experiment and not of theoretical speculation.

* J. Nicklès, On the Permeability of Metals to Mercury, [2], xv, 107.

† A sheet of platinum that has been for four months in contact with amalgam of sodium still preserves all its elasticity.

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Berthelot has observed still another series of hydrocarbons, between styrolene and retene, the boiling point of which is between 250° and 340°, and which possess to a great extent the characteristic fluorescence of pyrogenic oils of resin. Berthelot regards these hydrocarbons as C^4H^2 six, seven, and eight times condensed. Between 210° and 250° there passes over a liquid which, when placed in a freezing mixture, yields crystals of naphthaline. The origin of this interesting hydrocarbon is easily explained, naphthaline being in fact only pentacetylene less H^2.

$$\underbrace{C^{20}H^{10}}_{\text{Pentacetylene.}} - H^2 = \underbrace{C^{20}H^8}_{\text{Naphthaline.}}$$

Naphthaline is produced equally well when acetylene is passed into a tube heated to redness. There is, however, in this case but a small quantity formed, for the acetylene is chiefly decomposed into carbon and hydrogen.

Acclimation of the Camel in Australia.—The introduction of the camel into Australia has been previously announced, and it was effected by the "Société d'Acclimatation." We now learn that these animals have adapted themselves to that country, as has been shown by a recent expedition consisting of seventy horses, fourteen camels, and fifteen men. The springs of living water upon which they depended having been dried up, sickness broke out in the camp. The men fell back upon their stores of spirituous liquors, the horses took to flight, while the camels alone remained at their post. It is owing to this circumstance solely that the expedition was reorganized. At last accounts the caravan had arrived at Thompson river.

Acclimation of the Salmon.—The eggs of the salmon which have been introduced into the waters of Australia have hatched and the young fish are prospering. Ice has been used in the transportation of the eggs, which, according to Mr. Youle, retards the phenomena of embryonic evolution. This gentleman has found that the vitality of the eggs may thus be preserved for three or four months. It is in this manner that eggs taken from the Rhine at Huningen in Alsace have been successfully transported to Australia. Sweden and Norway are both occupied in stocking their rivers with salmon, so that the fine example of the Zoological Society of Acclimation will not be lost.

Spontaneous generation.—This interesting question is from time to time discussed by the Academy of Sciences, but without much progress being made toward a decision. Mr. Donné, a naturalist who formerly opposed the doctrine of spontaneous generation, has made some late researches which have caused him to change his mind on the question, and he has just ranged himself on the

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side of Messrs. Joly, Musset, and others, giving it as his opinion that spontaneous generation is a possible fact.

His later experiments, like those which he published an account of in 1863, were made with eggs. At that time he wrote: "The matter of which the egg is composed ought to be eminently suited to a primitive organization. I will leave the entire eggs to themselves, and when the alteration of their contents has well progressed, I will examine with the microscope the interior substance. If spontaneous generation is possible I ought to find organized beings there." The result was negative. Mr. Donné found neither mold nor infusoriæ, and he decided against spontaneous generation. Since then objections have been raised which decided Donné to resume his experiments. He reasoned thus: "The small quantity of air contained in the eggs was perhaps not sufficient to determine the phenomenon of a spontaneous generation, that is, to give life to a certain molecular arrangement of organic matter." Consequently he conducted his experiment in such a way that a larger quantity of air could have access to the eggs, the air having been previously deprived of any bodies it might hold in suspension, by passing through carded cotton. This time he obtained a generation of different kinds of mold, but found no traces of animalcules. He concludes 1st, "Microscopic vegetation may be produced at will in organic matter, left to itself, and protected from the intervention of foreign germs. 2d. Air is necessary to the development of infusorial animalcules. 3d. Air is indispensable to spontaneous generation in both kingdoms. The temperature of 30° is the most favorable to these productions."

To these conclusions the adversaries of the doctrine oppose their usual objections, viz., there were sources of error in the experiment, atmospheric germs in some way penetrated the eggs of which the shells were broken. The question thus remains still at the same point, and up to the present time it cannot be said to be experimentally resolved.

Mexican Scientific Commission.—This commission, instituted by M. V. Duruy, Minister of Public Instruction, continues its labors, which will perhaps be the only work to survive the unfortunate intervention of the French in Mexico. The commission is engaged solely with science, and may be judged of by what has formerly been said of it in this Journal, (Jan. 1866, p. 110). The third part of the second volume of its publications has appeared, containing geological papers by J. Marcou upon the frontiers between Mexico and the United States; by MM. Dolfus, Pavie, &c., upon Mexican volcanoes; and the geological sections from Vera Cruz to Mexico. Other papers are reports upon the Mexican fauna and flora, also upon the ruins of Uxmal and Mayapan, Ti-hoo and Izamal, &c.

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Bibliography.

Traité des propriétés des figures, par le General PONCELET. 2d edition, 2 vols. in 4°, avec planches.—This work, which is a complete *exposé* of this important subject, contains also the principal discoveries which the illustrious general has made in this department of inquiry. He has been engaged on the work since 1812, and was occupied with it when taken prisoner of war in Russia on the retreat from Moscow. The second edition, besides many improvements, contains *the general theory of the centers of harmonic means; polar reciprocity; analysis of transversals*, and their principal application to the projective properties of curves and geometric surfaces.

Cours d'algèbre superieure, par SERRET, Membre de l'Institut, Prof. au College de France, et à la Faculté des Sciences des Paris. 3d edit., 2 vols. in 8vo.—The first two editions of this work were disposed of with great rapidity. The third contains many improvements by the author. While this learned man does not pretend that the work is a *complete* treatise upon higher algebra, it contains notwithstanding a body of doctrine which will be of great use to those geometricians who are engaged in this important branch of mathematical analysis.

Traité d'Astronomie pour les genes du monde. 2 vols. in 12mo, avec 2 planches and 162 figs. dans le texte.—This work contains a resumé of the lectures which Mr. PETIT has given during the last 27 years at the Observatory of Toulouse, of which he was director. The treatise is elementary, but calculations are not excluded. There are besides, in the form of notes, details and anecdotes in respect to important discoveries as well as distinguished astronomers.

Eléments de Mécanique, par Mr. VIEILLE. In 8vo, de 256 pages avec figures.—Vieille is Inspector General of the University of France. This work of his is designed for the use of the various colleges, and is fully adapted to that purpose.

Le Chimiste: a Journal of Chemistry applied to Arts and to Agriculture; published by HENRY BERGÉ, Professor of Chemistry at the *Musée de l'Industrie* at Brussels.—This journal appears semi-monthly, costs but 8 francs per year, and, according to its title, contains the novelties in the department of chemistry applied to the arts. Each part consists of 16 pages 8vo.

ART. XIV.—*On the supposed Tadpole nests, or imprints made by the Batrachoides nidificans* (Hitchcock), *in the red shale of the New Red Sandstone of South Hadley, Mass.;* by CHARLES UPHAM SHEPARD.*

No impressions belonging to this or any other geological formation surpass if they equal these in their extreme delicacy of surface and sharpness of outline, rivaling as they do in these respects the most perfect metallic castings. Dr. Hitchcock, by whom they were first described, has well observed concerning them, that even viewed by the side of the splendid specimens of foot-prints, rain-drops and other rock-markings displayed in the Ichnological cabinet of this college (Amherst), "they are the most attractive of all."

Dr. Hitchcock was led to conceive of and adopt the theory of their origin first suggested and made public by Prof. Silliman, Jr., and the late Capt. N. S. Manross, viz., that they proceeded from the gyratory movements of tadpoles; though he very cau-

* Several excellent photographic representations accompanied this paper, which are omitted, as it was impossible to do them justice on wood.

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tiously observes, "in concluding that the impressions were made by batrachians similar to those now living, I am by no means free from doubts as to the identity of the phenomena."* The single figure he has given† (Pl. L, fig. 1) of these markings, if taken by itself does certainly favor the hypothesis adopted; though it fails in its uninterruptedly smooth and continuous surfaces as compared with the rough and broken sides of the recent tadpole cavities,—not to mention the rounded borders to the edges of the latter, when contrasted with the hexagonal outline of the corresponding part in these specimens. The cavities made by tadpoles morever are without any order in respect to each other, and vary somewhat among themselves in size and depth. Occasionally also, unoccupied spaces are seen between the holes, whereas in the shale nothing is more striking than the general uniformity among the impressions, and the very complete manner in which the entire surface is covered by them,—raised lines (sometimes resembling swollen veins), being the only boundaries between contiguous cavities.

The slabs of shale present three rather distinct varieties of these impressions, one of which is very accurately represented in the plate above referred to. In this the depressions are imperfectly arranged in rows, with a marked tendency to a concentric arrangement. The borders of the cavities are distinctly hexagonal, and the edges often equilateral. The cavities have a depth equal to about one-eighth their diameter. They are perfectly symmetrical, smooth and glossy. In a few of the specimens, the sides and bottoms are slightly pitted with ovoidal bodies of the size and shape of coarse gunpowder. The slab removed from such a surface of course exhibits upon its convexities corresponding granules in relief. As they are distributed without any order, and not generally present, they would appear to be due to seeds, as these of a larger size and spherical form are frequent in the formation.

In the second variety we have little more than the strongly nerved outlines of the hexagons. The cavity is shallow, or nearly obsolete; but on its bottom, and proceeding from one and the same side relatively in each impression, is often seen a tripartite, flame-like marking, or brush, which spreads over nearly half the area. The direction of this fan-shaped brush is constant throughout the series, thus evincing an origin from a common cause, and one that acted simultaneously. The impressions moreover are occasionally traversed by raised lines proceeding from a subjacent layer, and thereby subdivided into smaller compartments; but in these instances it is always easy to trace the hexagonal boundaries of the superior layer. The depressions are obviously arranged in rows, somewhat approximating to fur-

* Ichnology of New England, 4to, 1858, p. 122. Boston. † Idem.

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rows, the parallel sides of which are more conspicuous than the transverse edges which subdivide the furrows into cells.

It may here be observed that the fan-shaped brush is scarcely at all visible in the first described variety. The diameters of the cavities in both are the same, being from one to one and a half inches. The differences in the depth of the cavities in the two varieties probably grew out of the hardness of the bottom where they originated.

The second kind, or shallow impressions, are constantly associated with the third variety presently to be described, being situated from one-quarter to one-third of an inch only above them. A series of singularly interrupted and overlapping wave lines, obviously the remains of the parallel or zigzag, furrow-edges of the second variety above described, plainly enough show that they were produced by ripple action, through a gentle current of water setting transversely across the furrow-ridges.

The third kind of impressions is considerably different from either of the foregoing, and requires a more particular description. The hexagons are disposed in long, nearly straight, parallel series, though now and then a row suddenly runs out where it abuts directly against a furrow-ridge; or in other words a ridge is seen to bifurcate, or to be replaced by a furrow. The cavities in this variety have nearly double the breadth or area of the two first varieties. In hexagons of the third variety the two opposite sides that are at right angles to the furrows have treble the length of the other two pairs, which seemingly have been shortened at their expense. The angles of the hexagon also are not equal. The four situated at the extremities of the longer sides, are less than 110°, while the two remaining (transversely opposite) ones are over 130°. The four shorter edges moreover are often flattened down into a broad band, while the long transverse ridges remain thin and sharp, though not straight at top, but gently arcuated. Indeed they are sometimes so low and faint as to become almost obsolete, thus changing the row of cells almost into a trough, whose borders are composed of the shorter zigzag sides of contiguous hexagons (under angles of 130°);—the whole seeming to have originated in a contraction of these sides, and a corresponding elongation of those at right angles to the furrow. The flattened band is not perfectly horizontal, but inclines a little toward the bottom of the trough, and constantly in one direction throughout the series,—its lower side being situated upon the upper or most shallow side of the hexagonal cell or cavity, or in other words the greatest depression in the furrow adjoins the superior edge of the band—it being kept in mind that the greatest concavity in the cells is never central but always somewhat marginal. In some of the slabs the furrow-edges are much less deeply truncated, rarely they are flatly

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bevelled; and in one case for a little distance, I have seen them replaced by four narrow planes. But the most singular feature of those specimens with a single broad band, consists in the presence upon it of a circular scar, which is uniformly located between the large angle of 130° and the adjoining smaller one of 110°, just in one corner of the impression, and always in the same corner relatively, throughout the series. Its diameter is about one-fifth of an inch, and it would appear to have arisen from the presence of some adhesive matter at these points which has operated to interfere with the usually easy cleavage of the shale, whereby several layers of it have remained adhering together, producing either a depression or an elevation upon it, according as the scar is found on one side or the other of the separated shale. In addition to the foregoing, the tripartite brush is seen radiating directly from the scar, obliquely into and nearly across the bottom of the contiguous depression, pointing as it were to the scar on the contiguous band.

It should further be mentioned that the repetitions of these impressions of each separate sort are very numerous, and each equally smooth, sharp and perfect, through a thickness of from one-third to half an inch, and in every instance where overlapped by a different variety, the parallelism of the rows is very obvious.

The difficulties in the way of the tadpole theory early induced me to question it as explaining the above appearances; and I was led to seek other modes of accounting for the phenomena more in harmony with the facts. For a time, at the suggestion of a very eminent authority in comparative anatomy, I endeavored to find an explanation in the supposition that they proceeded from the spawn of gigantic batrachians, whose footprints at neighboring localities are so common in shale of the same formation. But such an origin, besides other incompatibilities, required an organized association of the ova into a flat tier or mat, made up of parallel rows (one egg in depth), for rods in length and many feet in width. No reptilian germs are known to be extruded in such a shape. My next conception was, that the imprints may have owed their origin to a gigantic species of alga, allied to the *Hydrodictyon utriculatum*, though constituting a different genus, and possibly pertaining to a different family altogether, of these fresh-water plants.

A recent mineralogical visit to the granite quarries of Rockport at Cape Ann, by bringing under my inspection a very remarkable exhibition of ripple-marks upon the sea-shore, leads me to refer the South Hadley imprint to a similar cause. The recent ripple-marks occur in a very striking manner almost directly in rear of the Sandy Beach Hotel, in a somewhat sheltered place at the head of a little bay or cove, where the

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sand is fine and the bottom hard. A gently swelling, elongated bar, six or eight rods in length, running parallel with the shore is here found. Its breadth is about half its length, and its elevation where the highest, twelve or fifteen inches above the narrow flat creek-bottom between it and the shore. The breadth of this interval does not exceed ten or fifteen feet, the middle half of which is nearly flat, while the sides therefrom slope upward very gradually each way. The bar is left bare at about half tide. The water flows in and out of the creeklet at both ends of the bar, and when the tide is sufficiently high, flows back and forth cross-wise, to the bed of the creek. During the rising of the tide, the bed of this elongated depression is more or less covered with water for nearly an hour before the bar is wholly submerged. Throughout this period, as well as at all other times while accessible, and best of all, at low water, when the surface is left wholly bare, an almost perfect repetition of the second and third varieties of the South Hadley impressions is every where visible, though the size of the cavities is constantly from two to threefold that of the fossil specimens. With singular precision may be seen the parallelism of the furrows (corresponding with the sea-margin), the cross partitions (though generally more faint than in the shale), the zigzag margins formed by those sides of the cells which give rise to the furrow-ridges, the frequent splitting of a ridge so as to form an additional (an interpolated) furrow, the smoothing down of a ridge so far as to produce the flat band, and the almost constant occurrence of the deepest part of the trough on the down-hill side of the furrow. Other coincidences might be pointed out with the aid of drawings; but the foregoing are perhaps sufficient for our purpose. The appearances remained in full view during several days of calm weather, the pattern being only slightly interfered with, during the ebbing and flowing of the tide. At low water the configuration of the surface was invariable.

The examination of these sea-shore markings led me to recur to a large sandstone slab (with a surface two feet square) procured two years ago from the Forrest-marble Oolite of Wiltshire, England, on account of its crustacean foot-prints. Here also we are presented with ripple-marks of the same regularity as on the Rockport beach. In area, the cavities are just half way between those from the sea-shore and those from the New Red Sandstone. The zigzag lines of the furrow-ridges, the position and distinctness of the transverse partitions, the greater depth of the cavities constantly toward one side rather than in the middle of the furrows, and the occasional bifurcation of the ridges, so as to embrace an additional trough are all plainly conspicuous. This specimen taken along with the Rockport sea-shore ripples leave no remaining doubt in my mind that the ori-

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gin of the appearances in all three of the cases is ascribable to the same cause: viz., to a wave-like, vertical motion produced by the air on the surface of nearly still water, combined with feeble horizontal currents (acting in directions nearly at right angles to each other) upon the bottom.

Amherst College, Oct. 15, 1866.

ART. XV.—*On a Theory proposed by Fresnel, and on a mode of measuring the average size of very fine particles;* by OGDEN N. ROOD, Prof. of Physics in Columbia College.

IF the light from a candle-flame be received on a ground glass surface, so obliquely that the incident ray makes only a very small angle with the glass surface, the light will be copiously reflected, and a bright uncolored image of the flame will be seen by reflexion. As the angle made by the incident ray is increased, the reflected image becomes first yellow, then red, and finally disappears altogether.

Fresnel has attempted to account* for this fact, on the ground that the more refrangible rays, having shorter wave-lengths, are caused to interfere by a difference of path, which is still too small to effect complete interference in the case of the longer waves of red light; the difference in path, depending on the depth of the minute scratches on the surface of the glass, and on the angle which the ray makes with this surface.

As it is not difficult to measure approximately the angle at which the red ray ceases to be reflected, it would be easy to put this theory to the test of experiment, if the average depth of the scratches on the ground surface were known.

The impossibility of obtaining such measurements, has hitherto prevented this theory of the action of finely roughened surfaces on light, from being either confirmed or overthrown.

Some time ago, while experimenting on a plane polished surface of glass which had been smoked with lamp-black to complete opacity, I was surprised to find that the lamp-black surface, at a great obliquity, reflected all the rays of light with much brilliancy, so that it resembled in appearance a polished surface of metal or glass. With less degrees of obliquity the reflected light was yellow, red, and finally disappeared altogether.

The lamp-black surface in this experiment was obtained from burning paraffine, and it was found that the red ray ceased to be reflected at an angle of 18°, reckoning from the glass surface. The source of light was a small gas-flame and the experiments

* Pogg. Annalen, Bd. xii, p. 210.

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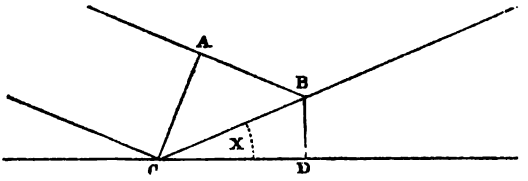
were made in a darkened room at night, the glass plate with its lamp-black surface, being attached to the axis of a graduated circle, the lamp-black having been removed from the upper half of the plate, so as to allow the proper adjustments to be made with the aid of the naked glass surface. I then attempted to measure with the microscope the average size of the smaller and more numerous particles of lamp-black; the result obtained was that they varied in size from ·000018 to ·000012 of an inch. Several months *afterwards*, I made a calculation to ascertain what the difference in the path of the interfering rays would be, using these data, and what relation this difference bore to the length of a wave of red light.

Assuming the dimensions of the particles of lamp-black to be the same in all directions, we have the annexed construction. BD will represent the diameter of a particle of lamp-black, the ray AB is reflected from its surface, the ray CB from the layer next below; X is the angle made by the light with the plate, and the difference in path of the two rays will evidently be equal to CB —AB, a quantity readily found by calculation.



Taking the size of the lamp-black particles to be equal to ·000018 of an inch, the difference in path of the two rays for an angle of incidence of 18° is ·000011, while the wave-length of the line C in the red space is nearly ·000026 of an inch. This shows that the difference in the path is not far from half a wave-length of red light, if the larger of the two estimates of the size of the particles of lamp-black is employed.

I then made a new set of experiments relative to the angle at which the red ray disappears, using as before lamp-black from paraffine. This was found to vary somewhat in different portions of the same plate, as is seen in the table below.

21°, 20°·75, 18°·75, 20°, 20° = 20°·1

New microscopic measurements on the size of the lamp-black particles were made with a different microscope, the value of the micrometer not being known; it was estimated that the size of the smaller and more numerous particles varied from $\frac{1}{45000}$ to $\frac{1}{50000}$ of an inch, but that there were more particles approaching the first number than the second, a circumstance of which I have not taken any advantage in the following calculation.

Taking the mean of these determinations, and combining it with the mean of the first determination, we obtain for the mean size of the particles $\frac{1}{6845}$ = ·0000146 of an inch.

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The average angle of disappearance of the red ray being 20°, there results a difference of path = ·0000998; that is, the difference of path is to the wave-length of red light nearly as 10 to 26.

When the difficulty of obtaining an approximate measurement of the size of the particles of lamp-black is considered, it is surprising to see how nearly the calculated difference in path approximates to half a wave-length of the light in question.

I found that a surface of magnesia produced by smoking a glass plate to opacity with burning magnesium wire, also reflected light in the same way at very oblique incidences. It was ascertained that the final tint was red, and that the red rays themselves disappeared at 11°. The size of the particles of magnesia was estimated at ·000036. Long after the measurements had been obtained I calculated the difference of path for the interfering rays; this was found to be,

	·000014
wave-length of C	·000026

giving a still nearer approximation to a difference of ½ a wave-length.

These experiments then seem to point out the correctness of Fresnel's theory, and we should I think be justified in reversing the process, and using the angle of disappearance of the red ray, in connexion with the known wave-length of this ray, for the purpose of calculating the average size of small particles or the average depth of fine scratches or furrows.

I give below the calculated values of the average size of the particles of lamp-black and magnesia.

Lamp-black from paraffine,	·0000188 calculated.
" " "	·0000146 measured.
Size of particles of magnesia,	·0000338 calculated.
" " "	·0000361 measured.

Some experiments were made on the angle of disappearance of the red ray with lamp-black produced by the burning of different substances; where the figures are connected by a bracket it is intended to indicate that the two angles were obtained from the same portion of the plate.

Lamp-black from stearine.	Lamp-black from camphor.	Lamp-black from a solution of spirits of turpentine in alcohol.
18°·25	16°	22°
18 ·75	15 ·9	21
16	15 ·1	20
16	15 ·4	
17°·25	15°·6	21°

It would appear from these last experiments that the average size of the particles of lamp-black from burning camphor is somewhat greater than from paraffine, while in the case of "burning-fluid" the particles are smaller.

New York, Dec. 4th, 1866.

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SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On a new form of magneto-electric machine.*—When the armatures of an ordinary magneto-electric machine with permanent steel magnets are wound with coarse wire, currents of electricity are obtained which are capable of developing magnetism in an electro-magnet. It is easy to see that the magnetism thus developed may in its turn be made to generate a current of electricity, and that this again may induce magnetism in a second and larger electro-magnet, and so on alternately. Mr. H. Wilde has availed himself of this principle to construct magneto-electric machines of extraordinary power. As the author's descriptions are not very clear, even with the aid of figures, we shall content ourselves with giving the general construction of the apparatus and the results obtained with a particular machine. In this machine the generator or primary source of the electric current was a magneto-electric machine consisting of six small permanent magnets weighing only one pound each and capable of lifting collectively a weight of, at most, 60 lbs. The current from this excites an electro-magnet weighing three tons, the total weight being about four and a half tons. The armatures are driven at a uniform velocity of 1500 revolutions per minute by means of a steam-engine and a very strong leather belt. With this machine pieces of iron rod fifteen inches in length and one-fourth of an inch in diameter were melted. With an intensity armature a light was obtained between points of gas carbon sufficiently intense to cast shadows from the flames of street lamps at a distance of a quarter of a mile. It is easy to see that by passing the current derived from the electro-magnet through another and larger electro-magnet a vast increase of electric force could be obtained, of course at the expense of a greatly increased motive power. With an unlimited increase of motive power an unlimited increase of electric force could be obtained, as in fact the whole machine is to be regarded as a means for transforming heat into mechanical power, and this last into electricity. It is to be regretted that the author has given no precise data from which the amount of electricity set free can be determined with precision. The quantity of water decomposed per minute, with the expenditure of a measured amount of mechanical work, is what we require in order to form a correct estimate of the value of the apparatus, as compared with that of other electro-motors. In any case, however, it is safe to predict a brilliant and useful future for the new apparatus.—*Proc. of Royal Society*, xv, 107. W. G.

2. *On the synthesis of chlorid of thioxyl.*—Wurtz has made the very interesting observation that chlorid of thioxyl, $S_2O_2Cl_2$ or $S\cancel{O}Cl_2$, may be produced by the direct union of anhydrous hypochlorous acid with sulphur,

$$Cl_2\cancel{O}+S=S\cancel{O}Cl_2.$$

The vapor of hypochlorous acid is passed into chlorid of sulphur holding sulphur in suspension, and the operation is discontinued as soon as the sulphur has entirely disappeared. The chlorid of thioxyl may then be separated from the chlorid of sulphur by distillation. Chlorid of thioxyl

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as thus prepared is a colorless liquid which has a penetrating odor reminding of sulphurous acid and chlorid of sulphur. Its density at 0° is 1·675, and its boiling point 78° at 746 mm. Water resolves it into chlorhydric and sulphurous acids, $S\Theta Cl_2 + H_2\Theta = 2HCl + S\Theta_2$.

Liquid hypochlorous acid explodes on contact with sulphur, and it is for this reason that the action must be moderated by suspending the sulphur in chlorid of sulphur and keeping this at a temperature of −12° C. From the above it is clear that $Cl_2\Theta$ may unite directly with a radical, a fact which stands related to the observation of Carius that $HCl\Theta$ unites directly with certain hydrocarbons.—*Comptes Rendus*, lxii, 460.

W. G.

3. *On a new series of hydrocarbons.*—SCHORLEMMER has discovered among the products of the distillation of cannel coal, besides the homologues of marsh gas and benzol, other hydrocarbons attacked by concentrated sulphuric acid. When the oil, after treatment with the acid, is distilled, the oils of the benzol and marsh gas series pass over first and there remains a black tarry mass. If this mass be distilled, a thick brown liquid with an offensive smell passes over between 300° and 400°. By repeated distillations with caustic alkali and with sodium a series of carburets may be obtained with the general formula $(C_nH_{2n-2})_2$; of these the author describes $C_{12}H_{20}$, $C_{14}H_{24}$, $C_{16}H_{28}$. These are all colorless oily highly refractive liquids, having a faint peculiar smell resembling that of the carrot or parsnip root. These oils unite with bromine to form colorless heavy liquids easily decomposed by heating. A molecule of oil takes up two atoms of bromine. Strong nitric acid dissolves the oils, forming nitro-compounds which with tin and chlorhydric acid give organic bases. With sulphuric acid and bichromate of potash the oils yield carbonic, formic, acetic, and perhaps other acids. The author considers it certain that the oils of this series are polymers of the acetylene series.—*Annalen der Chemie und Pharm.*, cxxxix, 244. W. G.

4. *On the compounds of tantalum.*—MARIGNAC has published the conclusion of his researches on niobium and tantalum, the first part of which has already been noticed in this Journal. To determine the atomic weight of tantalum, pure crystallized fluotantalate of potassium, $KF.TaF_5$, was treated with concentrated sulphuric acid and carried finally to a temperature of 400° C. On boiling with water, bisulphate of potash is dissolved out and sulphate of tantalum left in small granular crystals, which by strong ignition yield tantalic acid. The bisulphate of potash is brought by evaporation and ignition to the state of sulphate and weighed as such. Four analyses closely agreeing with each other gave the number 182·3 as the atomic weight of tantalum; a molecule of tantalic acid has therefore the formula $Ta_2\Theta_5$, and the molecular weight 444·6. The analysis of the fluotantalate of ammonium leads to the number 182 as the atomic weight of tantalum, and this number is adopted by Marignac as most probable. The author remarks that the difference between the atomic weights of niobium and tantalum, which belong to the same natural family, is the same as that between the atomic weights of the closely allied metals, tungsten and molybdenum, namely, 88. Tantalic acid forms two classes of salts, in one of which it is monobasic and in the other quadribasic. The first class have the formula

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$Ta_2\Theta_5.M\Theta$, and the second the formula $3Ta_2\Theta_5.4M\Theta$: the tantalates of soda and potash belong to this last type and crystallize well. The oxyd and sulphid of tantalum described by Berzelius and others have respectively the formulas $Ta\Theta_2$ and TaS_2. Chlorid of tantalum has the formula $TnCl_5$; the calculated density of its vapor is 12·84, while Deville and Troost find 12·42. Tantalic acid not ignited dissolves easily in fluohydric acid and forms soluble and crystallizable salts with other fluorids, but it does not appear that there is a class of oxyfluotantalates corresponding to the oxyfluoniobates. The fluotantalate of potassium, $TaF_5.2KF$, crystallizes in the right rhombic system and is isomorphous with the corresponding fluoniobate. When boiled for a long time with water the salt changes to an insoluble body having approximately the formula $Ta_2\Theta_5+2(2KF.TaF_5)$, which may, however, be only a mixture. The formation of this insoluble compound gives the means of detecting the smallest quantity of fluotantalate in the oxyfluoniobate of potassium. Two fluotantalates of sodium have respectively the formulas TaF_5, $2NaF+H_2\Theta$ and $TaF_5 3NaF$. The other salts described are TaF_5, $2NH_4F$, TaF_5, $2ZnF+7aq.$, and TaF_5, $2CuF+4aq$. In our first notice of Marignac's researches we have stated that that chemist had detected in niobite a small quantity of an acid which might prove to be new. Further investigation has, however, shown that this is titanic acid.—*Bull. de la Soc. Chimique*, Aug. 1866, pp. 118 and 115. W. G.

5. *On the preparation of iodhydric and phosphoric acids.*—PETTENKOFER has given a very elegant modification of Liebig's process for the preparation of iodhydric acid and alkaline iodids, and has further extended the method so as to obtain pure phosphoric acid as a subsidiary product. To half an ounce of common phosphorus in twelve ounces of distilled water at 60° or 70° C. one ounce of iodine out of eight ounces is to be added. The whole is to be stirred and the liquid poured off from the phosphorus and iodid of phosphorus upon the remaining seven ounces of iodine contained in a separate vessel. The solution of iodine as thus obtained is to be poured back upon the phosphorus and the alternate process repeated until all the iodine is dissolved and has come in contact with the phosphorus. The red-brown liquid last obtained becomes almost colorless after a short time, and there remains only a little red phosphorus. The filtered liquid, consisting of water, iodhydric, phosphorous and a little phosphoric acid, is to be distilled over an open fire till the liquid becomes syrupy. The distillate consists of iodhydric acid containing a little free iodine, and has a specific gravity of 1·39 to 1·40. It appears to keep well and serves for the convenient preparation of the iodids of potassium, sodium, calcium, &c. Saturated with bicarbonate of potash the acid yields on evaporation and crystallization a pure iodid in perfectly colorless crystals. The contents of the retort are to be poured out, the retort washed, and a few drops of concentrated nitric acid containing nitrous acid added, when the whole remaining iodhydric acid is decomposed into water and free iodine. The free iodine may be separated by filtration, after which the filtrate is warmed till it becomes colorless. The filtrate is then to be evaporated with about one and a half ounces of nitric acid of 1·20, added in small portions at a time until, on addition of pure acid, nitrous acid fumes are no longer evolved. The so-

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lution of phosphoric acid is then to be evaporated till the vapor arising no longer reddens litmus. In this manner a pure phosphoric acid, free from arsenic and sulphur, was obtained, although the phosphorus employed contained traces of both substances.—*Ann. der Chemie und Pharm.*, cxxxviii, 57. W. G.

6. *On crotonic acid.*—BULK has given another instance of the conversion of one organic acid into another by simple addition of one molecule or two atoms of hydrogen. When crotonic acid, $C_8H_6O_2$, is heated with an amalgam of sodium or with metallic zinc and dilute sulphuric acid, it passes gradually into butyric acid, $C_4H_8O_2$, this last being in the modification in which it is obtained by fermentation.—*Ann. der Chemie u. Pharm.*, cxxxix, 62. W. G.

7. *On syntheses of guanidin.*—A. W. HOFMANN has succeeded in the synthesis of guanidin, $N_3\left\{\begin{matrix}\overset{iv}{C}\\H_3\\H_2\end{matrix}\right.$, by two different processes. An alcoholic solution of chlorpicrin, $C(NO_2)Cl_3$, and ammonia is heated for some time in a closed tube to a temperature of 100°. Under these circumstances the reaction occurs which is represented by the equation

$$C(NO_2)Cl_3+3NH_3=CH_5N_3,HCl+2HCl+HNO_2.$$

When orthocarbonic ether is heated to 150° C. with aqueous ammonia, guanidin and alcohol are formed, according to the equation,

$$C(C_2H_5)_4O_4+3NH_3+H_2O=CH_5N_3,H_2O+4(C_2H_5,HO).$$

The author suggests that the corresponding orthosilicate of ethyl, $Si(C_2H_5)_4O_4$, may by a similar process yield a species of guanidin in which silicon takes the place of carbon, and also that the well known compounds formed by the action of ammonia upon the chlorids of silicon and titanium may be simply mixtures of sal-ammoniac with the chlorhydrates of guanidin containing silicon or titanium in place of carbon.—*Ann. der Chem. u. Pharm.*, cxxxix, 107. W. G.

8. *On flame reactions.*—BUNSEN has made a systematic study of the action of different parts of the flame of the well known burner which bears his name, on various substances, either alone or mixed with fluxes and other reagents. As no mere abstract can do justice to a paper of this character we must refer our readers to the original. It can hardly be doubted that, wherever gas can be had, the flame of the burner will soon supplant the ordinary mouth blowpipe in testing upon a small scale by heat.—*Ann. der Chem. u. Pharm.*, cxxxviii, 257. W. G.

II. MINERALOGY AND GEOLOGY.

1. *Geological Survey of Illinois;* A. H. WORTHEN, Director. Volume I, *Geology.* xvi, and 504 pp. royal 8vo, with map, sections, &c. 1866, Springfield. Published by authority of the Legislature of Illinois.—In the September number of this Journal, we gave a brief notice of the issue of this valuable Report, it having reached us so near our publication day, that we were unable to do more than merely acknowledge its reception, and promise a more extended notice in a future number. Circumstances beyond our control prevented the preparation of this notice in

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time for the November number, but we now propose to fulfil the promise, so far as limited space will permit.

As stated above, this Report occupies about 520 pages of letter-press, and is printed in large clear type, upon excellent paper, with well executed illustrations; and the whole is neatly and substantially bound in cloth. Chapter I consists of remarks on the General Principles of geological science,—the physical features of the State, its Surface geology, &c. In Chapter II the Tertiary deposits and the Coal-measures are described and their relations to the other formations of the state explained, by a section showing the thickness, order of succession, &c., of the various rocks occurring in Illinois. The Tertiary, consisting of various colored clays, greenish sand, &c., occupies but a limited area in the southern part of the state, and has yet afforded only a few imperfect casts of fossils, apparently of Eocene age.

The Coal-measures being of great economical importance, are described at length, and numerous sections of their various beds are given, as ascertained from natural exposures, borings, shafts, &c. Contrary to an opinion somewhat current among geologists, the State Geologist maintains that the Illinois coal-field is not broken up into several isolated patches, separated by intervals of older rocks, but is a continuous field, occupying near three-fourths of the entire area of the State. The maximum thickness of the whole series, exclusive of the Millstone grit, is, in the southern part of the State, about 900 feet, including six workable beds of coal, with an aggregate thickness of 30 feet. Going northward, the Coal-measures diminish in thickness, chiefly by the thinning out of lower beds, so that on the northern borders of the field, where the Millstone grit and Subcarboniferous rocks are wanting, some of the higher members are found resting directly down upon Devonian and Silurian rocks: thus apparently showing that as far back at least as the commencement of the Subcarboniferous period, the northern part of the state was more elevated than the southern, and that as the subsidence of the whole area progressed, the successive newer beds extended farther and farther northward. The whole series being, with one or two local exceptons, almost entirely undisturbed by upheavals, flexures, faults, &c., the miner meets with few of the obstacles here, that so materially diminish the profits of coal mining in more disturbed districts. From the facts given, it is evident that we can scarcely overestimate the value and importance of this inexhaustible store of mineral wealth, as a source of power and progress, to a state like Illinois, which also has a vast extent of the most beautiful undulating prairie lands unsurpassed in productiveness and easily brought under cultivation.

In regard to petroleum in Illinois, the State Geologist remarks that it has been found in small quantities in two or three of the southern counties; and that from the greater thickness, on the eastern borders of the State, of the rocks generally regarded as the source of the oil deposits in western Pennsylvania and eastern Ohio and Kentucky, it will be most apt to be found in paying quantities in the region of the Wabash valley. The correctness of this suggestion has been confirmed since the printing of the Report, by a valuable flowing well sunk at Terre Haute, Indiana.

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In Chapter III, the various Subcarboniferous rocks are fully described in the order of their succession from above, and various analyses by the late Henry Pratten, Esq., showing their chemical composition are given. The thickness, geographical range, general physical characters, characteristic fossils, &c., of each of these rocks are also stated in considerable detail. This chapter likewise includes an interesting Report by Prof. G. J. Brush of Yale College, on the geodes so abundant at the Rapids of the Mississippi in the Keokuk beds.

The Devonian and Silurian rocks are similarly treated of in chapter IV; while in chapter V, we have a valuable and highly interesting Report on the Galena Lead region, by Prof. J. D. Whitney, now the State Geologist of California. Prof. Whitney's Report is illustrated by a large, neatly engraved and colored map of the Lead region, on which the boundaries of the several formations, the position and bearings of lead crevices, and the general topography of the country are accurately laid down. It also contains another map on a larger scale, of the country around Galena, on which similar information is given in more detail: likewise a columnar section showing the various rocks that occur in the lead district, their thickness, composition, order of superposition, &c. As it would be impossible in a notice like this, to give an intelligible idea of the amount of statistical and scientific information contained in this Report, respecting the mode of occurrence of the ore, the methods pursued in extracting it, the processes of smelting, the yield of lead, &c., we must refer the reader to the Report itself for such details.

Chapter VI is composed of a Report by Prof. Leo Lesquereux, on the Coal fields of Illinois, giving a large amount of information respecting the structure of the Illinois Coal series, and the relations of its various beds and outcrops to each other, and to those of Kentucky, Arkansas, Indiana, Ohio and Pennsylvania, as determined by a careful study of the fossil plants found associated with each of these beds. From the long experience this gentleman has had in exploring the Coal-measures of the West, and his extensive knowledge of fossil Botany, it may be readily inferred that this chapter will be found full of interesting and practical information. In Chapter VII, he likewise discusses at length the mooted question respecting the origin and formation of prairies, which he thinks are due to the gradual disappearance of marshes.

The chemical Report of Dr. J. V. Z. Blany, chemist of the survey, constitutes Chapter VIII. This Report contains much valuable information, consisting of numerous analyses of coals, iron ores, &c., chiefly the former, with classifications and descriptions of the same.

The remaining portions of the volume consists of detailed county Reports as follows:—On Randolph county, St. Clair county, Madison county, Hancock county, and Hardin county, by the State Geologist. The Report on the latter county is illustrated by a neat colored map, and also includes an interesting Report on the Rosiclare Lead mines, illustrated by diagrams, plans of the different workings, &c., by Prof. J. G. Norwood of the University of Missouri. The following counties are reported upon by Mr. Henry Engelmann, viz:—Johnson, Pulaski, Massac and Pope. These county Reports are all in great detail, and contain a large amount of practical and scientific information.

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At the end of the volume, there is a copious glossary of scientific terms, followed by the index, and a neatly engraved section of the rocks seen along the Mississippi from the northern boundary of the State to Cairo.

This volume shows throughout that the survey of the State, so rich in resources, has been in the hands of an able and successful geologist. We earnestly hope that the Legislature may make the necessary appropriation this winter for a third volume, which we are informed the State geologist has in a forward state of preparation, including detailed reports of many county surveys, and other valuable information; and that nothing may prevent the onward progress of the survey to its final completion, and the publication of all the results. The publication of such reports not only advances the material interests of a State, by spreading useful information among the people, but by inviting capital, enterprise and emigration from other parts of our own country and from abroad.

2. *Contributions to the Paleontology of Illinois and other Western States;* by F. B. Meek and A. H. Worthen, of the Illinois State Geological Survey. (Proceed. Acad. Nat. Sci. Philad., July, 1866, p. 251.)—This paper contains descriptions of the following new species and genera of fossils from the Carboniferous rocks of the West:—*Belemnocrinus Whitii*, *Synbathocrinus Wachsmuthi* (type of a new subgenus *Nematocrinus*), *Cyathocrinus Farleyi*, *Rhodocrinus nanus*, *Onychocrinus diversus*, *Granatocrinus Shumardi*, *Schœnaster Wachsmuthi*, *Pteria* (*Pterinea?*) *Morganensis*, *Macrodon micronema*, *Platyceras lævigatum*, *Platyceras haliotoides*, *P. uncum*, *P.* (*Orthonychia*) *Chesterensis*, *P.* (*O.*) *subplicatum*, *P.* (*O.*) *infundibulum* (=*P. subrectum* Hall, 1860; not *P. subrectum* of the same author, 1859), *Metoptoma* (*Platyceras?*) *umbella*, *Polyphemopsis Chesterensis*, *Anomphalus rotulus* (type of a new genus allied to *Rotella*), *Microdoma conica* (type of a new genus), *Orthonema conica*, *Trochita? carbonaria*, *Pleurotomaria conoides*, *P. Coxana*, *P. spironema*, *P. valvatiformis*, *Murisonia inornata*, and *Nautilus* (*Cryptoceras*) *Rockfordensis*.

It also contains notices of two new genera of Crinoids, which are more fully described and illustrated in the second volume of the Illinois report. The first of these genera, *Strotocrinus*, is proposed for those greatly expanded species, such as *Actinocrinus perumbrosus*, *A. regalis*, &c., of Hall. Prof. Hall had proposed for this type the name *Calathocrinus*, which could not stand because von Meyer had previously applied it to another group in 1848. The other genus, *Steganocrinus*, is proposed for a curious group, of which *Actinocrinus pentagonus* of Hall is the type. This type differs from *Actinocrinus*, in having the rays, when found entire, greatly extended out horizontally in the form of slender, free, rigid arm-like appendages, covered all the way out by small pieces like the vault, and bearing the true arms along their lateral margins.

The authors likewise make some remarks on *Onychocrinus* of Lyon & Casseday, which they think most probably a good genus, though it has generally been regarded as a synonym of *Forbesiocrinus;* also on the genus *Platyceras* Conrad, which they think more nearly allied to the recent genus *Capulus*, than has been supposed in this country, though still generically distinct.

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Most of these fossils, and others previously described by the same authors, will be fully illustrated and more elaborately described in a future Report of the Illinois Survey.

3. *A Geological and Agricultural Survey of* 100 *miles west of Omaha;* by the American Bureau of Mines.* New York, 1866, 44 pp., 8vo.—This Report embodies the results of a reconnoissance made during the past summer by Prof. Thos. Egleston, along the line of the first hundred miles of the Union Pacific Railroad, west of Omaha, Nebraska. The survey was made under a commission from the railroad company, the chief object being probably to throw some light upon the question of the probabilities of finding workable beds of coal in that region, within accessible distances beneath the surface.

When it is remembered that the publications of previous explorers had made the general features of the geology of that part of the country so well known as to prevent the possibility of new and startling discoveries, it must be conceded that Prof. Egleston has made up quite an interesting report upon the physical features of the district explored—its agricultural capacities, climatology,† &c. He has also accurately described the Upper Carboniferous, Cretaceous, Drift, and alluvial formations previously known to exist there. From the Carboniferous beds he collected some thirty-five species of fossils, one of which (*Nautilus Illinoiensis*) had not, we believe, been before discovered at the localities mentioned. These fossils were identified by Mr. Meek,‡ and a list of them is given on pages 12 and 13 of the Report.

In regard to coal, Prof. Egleston thinks, from what is known respecting the structure of the Coal formation in northern Missouri and western Iowa, that workable beds may possibly be struck at a depth of 550 feet below the surface of the Missouri at Omaha, and at near 600 feet below the same horizon at Bellevue.

4. *Notes on the Geology of Western S. America;* by A. Rémond, (from a letter to Prof. W. H. Brewer, dated Santiago, Chili, Oct. 11, 1866).—The following are among the discoveries which I have made on the west coast of South America.

(1.) Jurassic fossils in the metamorphic rocks about Lima; some of the species strongly resemble those found in the belt of the same age in California.

(2.) At the Morro of Arica, lat. 18° 28′ S. on the coast of southern Peru, Jurassic species, one of them identical with fossils found by Dr. Philippi near Chaco, east of the Desert of Atacama, lat. 25° 12′ S.

(3.) A collection of fossil plants, probably of Triassic age, from the coal-bearing formation of northern Chili, a region previously unexplored by geologists. Some of these species are similar to those I brought from

* It should be here noted that the American Bureau of Mines is a private association, and not a government institution.

† The Smithsonian Institution's publications are credited for the meteorological data upon which the remarks on the climate are based.

‡ Our attention has been called by Mr. Meek to quite a number of typographical errors in this list of fossils, for which he is not responsible, as the list was not printed from a manuscript written by him, and he saw no proof of it as the Report went through the press.

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Sonora two years ago; and two of the species, a Pecopteris and a Pterophyllum, are probably identical.

(4.) At the silver mines of Tres Puntas and Chanarçillo, species of lower Cretaceous; and above the coal beds many species of Lias, but most of them have been found before by Prof. Domeyko at Las Juntas and Tres Cruces.

(5.) Eocene fossils at Caldera, lat 27° 4′. Near this port are also extensive beds of recent shells well preserved.

(6.) Near Coquimbo many species from the middle and upper Tertiary.

5. *Carta Geologica di Savoja, Piemonte e Liguria;* del commendatore ANGELO SISMONDA, Professore di Mineralogia nella Universita di Torino, etc. 26×31 inches, colored. Published by the Italian government.—This geological chart, by Prof. Sismonda of Turin, gives, in colors, the geology of perhaps the most interesting part of Europe. It covers northwestern Italy, west of Cremona and Milan, and extends north, across the Alps, to Lake Geneva and the Rhone. It hence exhibits the rock formations of Italy stretching north over the regions of the southern Alps. Thus we observe, among its many points of great interest, the region of crystalline rocks (protogine, gneiss, mica schist, etc.) in which stands Mt. Blanc, lying *within*, and trending with, the great Jurassic belt that divides Italy and France; this Jurassic formation to the westward of Mt. Blanc being mostly unaltered, while that on the east is metamorphic. The difficult geological problem of the Alps receives a large part of its solution from the facts observed in northern Italy.

6. *Comptoir Minéralogique of F. Pisani at Paris.*—Mr. Pisani has opened rooms for the sale of minerals in the same court recently occupied by the late Louis Sæmann, No. 6 Rue de Mézières. He is an excellent mineralogist as well as chemist, and many difficult points in mineralogy have been elucidated by his analyses. We take pleasure in commending his establishment to all who desire to procure minerals either by the specimen or cabinet.

7. *Discovery of additional Mastodon remains at Cohoes, N. Y.*—A few weeks after the discovery at Cohoes of the lower jaw of a mastodon, a notice of which appeared in the last number of the Journal (p. 426), some additional remains were found in the same locality; and subsequently the skull and many other parts of the same skeleton were brought to light. These also are in an excellent state of preservation, and the whole, when seen together, exhibit admirably the prominent characters of the species, as well as some structural peculiarities of much scientific interest.

The remains are evidently those of the common North American mastodon—*M. Ohioticus* (*M. giganteus* Cuvier). The imperfect ossification of some parts of the skeleton, especially the epiphyses, shows that the animal was comparatively young, while the absence of tusks from the lower jaw would indicate a full-grown female.

The missing portions of the skeleton are without doubt in the same pot-hole, which contained those already found, and, although their recovery may involve considerable expense, it is greatly to be hoped that all may be secured; as the skeleton would then be one of the most perfect ever discovered, and prove a most important addition to the New York

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State collection, in which, through the generosity of the Harmony Mills Co. of Cohoes, it is to be permanently deposited.

The pit, in which the mastodon remains were found, had evidently been formed by several pot-holes wearing into each other. It was about forty feet in diameter at the top, and forty in depth; and was filled chiefly with decayed vegetable matter, resembling peat, in which were imbedded many fragments of trees, mostly conifers. The arrangement of the materials showed that they had been deposited rapidly, and a part of a beaver dam, found near the bottom, would indicate that the whole had been swept in by a freshet. No other animal remains were found except those already mentioned, although the "beaver-sticks" probably indicate one cotemporary of the mastodon.

Some of the specimens of wood found with the skeleton, and evidently introduced at the same time, were sufficiently well preserved to admit of determination. Among these were noticed species of the white pine (*Pinus strobus* L.), the common hemlock (*Abies Canadensis* Michx.), the black spruce (*Abies nigra* Poir.), the American larch (*Larix Americana* Michx.), the swamp maple (*Acer rubrum* L.), and the white birch (*Betula alba* Spach.) O. C. M.

8. *A Catalogue of Official Reports upon Geological Surveys of the United States and British Provinces.*—In arranging a set of American Geological Reports in the Library of Yale College, the following catalogue became necessary; and it is here published in order that its inaccuracies and deficiencies may be noticed and corrected, while, in its incompleteness, it may be of assistance to some.[1]

PART I.—STATES EAST OF THE MISSISSIPPI RIVER.

MAINE.

1837. *Chas. T. Jackson*, 1st Ann. Rep., Augusta, 12mo, 128 pp. Atlas, 24 pl.
1838. *C. T. Jackson*, 2d Ann. Rep., Augusta, 12mo, 168 pp.
1839. " 3d " " 276 and lxiv pp.
1837. " 1st " Geol. of Public Lands, Maine and Mass., Boston, 12mo, 47 pp.
1838. *C. T. Jackson*, 2d Ann. Rep., Geol. of Public Lands, Maine and Mass., Boston, 12mo, 93 pp.
1839. *Ezekiel Holmes*, Explor. and Survey of Aroostook River Territory, 1st Ann. Rep., Augusta, 12mo, 78 pp.
1862. *E. Holmes* and *Chas. H. Hitchcock*, Nat. Hist. and Geol., 2d Ann. Rep., Augusta, 8vo, 387 pp.
1863. *E. Holmes* and *C. H. Hitchcock*, Nat. Hist. and Geol., Augusta, 8vo, 447 pp.

NEW HAMPSHIRE.

1841. *C. T. Jackson*, 1st Ann. Rep., Concord, 12mo, 164 pp.
1842. " 2d " " " 8 pp.

[1] Of those Reports marked with an * one copy is needed at the Library of Yale College; and also one copy of any Report not included in the list: persons having them to dispose of are requested to notify the Librarian.

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1844. *C. T. Jackson*, Final Rep., Concord, 4to, 379 pp., map, 2 sections.
1845. " Views and Map, illustrating Scenery and Geology, Boston, 4to, 20 pp., 8 pl.

VERMONT.

1845. *Chas. B. Adams*, 1st Ann. Rep., Burlington, 8vo, 92 pp.
1846. " 2d " " " 267 pp.
1847. " 3d " " " 32 pp.
1848.* " 4th " " " 8 pp.
1856. *Augustus Young*, Prelim. Rep. on Nat. Hist., Burlington, 12mo, 88 pp.
1857. *E. Hitchcock*, 1st Ann. Rep., Montpelier, 12mo, 12 pp.
1858. " 2d " Burlington, 12mo, 13 pp.
1861. *Edward Hitchcock*, *E. Hitchcock, Jr.*, *A. D. Hager*, and *Chas. H. Hitchcock*, Final Rep., Proctorsville, 4to, 2 parts, 988 pp., 38 pl.

MASSACHUSETTS.

1832. *E. Hitchcock*, Final Report (1st Part), Economic Geology, Amherst, 8vo, 71 pp.
1833. *E. Hitchcock*, Final Report (complete), Amherst, 8vo, 700 pp., Atlas, 19 pl.
1835. *E. Hitchcock*, Final Report (2d edition), Amherst, 12mo, 702 pp. Atlas, 19 pl.
1838. *E. Hitchcock*, Rep. on Reëxamination Economic Geol., Boston, 12mo, 139 pp.
1841. *E. Hitchcock*, Final Rep., Amherst, 4to, 831 pp., map and 55 pl.
1858. " Rep. on Surface Geology, Boston, 8vo, 44 pp.
1858. " " Conn. River Sandstone (Ichnology of New England), Boston, 4to, xii and 220 pp., 60 pl.
1865. *E. Hitchcock*, Supplement to Ichnology of New England, Boston, 4to, x and 96 pp., 20 pl.

RHODE ISLAND.

1840. *Chas. T. Jackson*, Final Rep., Providence, 8vo, 312 pp., map, section.

CONNECTICUT.

1837. *Chas. U. Shepard* (Mineralogy and Economic Geol.), New Haven, 8vo, 188 pp.
1842. *Jas. G. Percival*, Final Report, New Haven, 8vo, 495 pp., map.

NEW YORK.

1836. *John A. Dix*, Rep. on proposed Survey, Albany, 8vo, 60 pp.
1837. *John Torrey*, *James E. DeKay*, *Lewis C. Beck*, *Wm. W. Mather*, *Ebenezer Emmons*, *Timothy A. Conrad*, and *Lardner Vanuxem*, Ann. Rep., Albany, 8vo, 212 pp.
1838. (*The same, with exception of J. Torrey*, and addition of *Jas. Hall*,) Ann. Rep., Albany, 8vo, 384 pp.
1839. (*The same, with exception of J. E. DeKay*,) Ann. Rep., Albany, 8vo, 351 pp.
1840. (*The same*,) Ann. Rep., Albany, 8vo, 484 pp.

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1841. (*The same,*) Ann. Rep., Albany, 8vo, 184 pp.
1842. *L. C. Beck*, Final Rep. Mineralogy, Albany, 4to, 536 pp., 8 pl.
1843. *W. W. Mather*, Final Rep. 1st Dist., Albany, 4to, 653 pp., 46 pl.
1842. *E. Emmons*, Final Rep., 2d Dist., Albany, 4to, 427 pp., 17 pl.
" *L. Vanuxem*, Final Rep., 3d Dist., Albany, 4to, 306 pp.
1843. *J. Hall*, " " 4th " " 4to, 525 pp., 19 pl.
1847. " " " Paleontology, Vol. I, Albany, 4to, 338 pp., 100 pl.
1852. *J. Hall*, Final Rep., Paleontology, Vol. II, Albany, 4to, 362 pp. 104 pl.
1859. *J. Hall*, Final Rep., Paleontology, Vol. III, Albany, 4to, 532 pp., 140 pl.
1846. *E. Emmons*, Final Rep., Agriculture, Albany, 4to, 371 pp., 21 pl., map. (Contains Emmons's "Taconic System.")
1850. *J. Hall*, 3d Reg. Rep., Appendix L, Contrib. to Paleontology, Albany, 8vo, 13 pp., 3 pl.
1857. *J. Hall*, 10th Reg. Rep., Appendix C, Contrib. to Paleontology, Albany, 8vo, 148 pp.
1859. *J. Hall*, 12th Reg. Rep., Appendix — Contrib. to Paleontology, Albany, 8vo, 90 pp.
1860. *J. Hall*, 13th Reg. Rep., Appendix F, Contrib. to Paleontology, Albany, 8vo, 76 pp.
1861. *L. Lincklaen*, 14th Reg. Rep., Appendix B, Guide to Geology N. Y., Albany, 8vo, 68 pp., 19 pl.
1861. *J. Hall*, 14th Reg. Rep., Appendix C, Contrib. to Paleontology, Albany, 8vo, 22 pp.
1862. *J. Hall*, 15th Reg. Rep., Appendix —, Contrib. to Paleontology, Albany, 8vo, 170 pp.
1863. *J. Hall*, 16th Reg. Rep., Appendix D, Contrib. to Paleontology, Albany, 8vo, 210 pp. 11 pl.
1864. *J. Hall*, 17th Reg. Rep., Appendix H, Albany, 8vo, 11 pp.
1866. " 18th " " —, " "

New Jersey.

1836. *Henry D. Rogers*, 1st Rep., Philadelphia, 8vo, 188 pp., map.
1840.* *Henry D. Rogers*, Final Rep. (Descr. Geol. N. J.), Philadelphia, 8vo, 301 pp., map. (Reprinted without map, Trenton, 1865.)
1855. *Wm. Kitchell*, 1st Ann. Rep., New Brunswick, 8vo, 100 pp.
1856. " 2d, " Trenton, 8vo, 248 pp.
1857. " 3d, " " 79 pp.
1857. *Geo. H. Cook*, Rep. on Cape May Co., Trenton, 8vo, 211 pp., map.
1864. " 1st Ann. Rep., Trenton, 8vo, 13 pp.
1865. " 2d " " 24 pp., map, section.

Pennsylvania.

1836. *H. D. Rogers*, 1st Ann. Rep., Harrisburg, 8vo, 22 pp.
1838. " 2d " " " 91 pp.
1839. " 3d " " " 119 pp.
1840. " 4th " " " 252 pp.
1841. " 5th " " " 179 pp.
1842. " 6th " " " 28 pp.

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1858. *H. D. Rogers*, Final Rep., Vol. I, Philadelphia, [printed at Edinburgh.] 4to, xxvii and 586 pp., 27 pl., 8 sect.
1858. *H. D. Rogers*, Final Rep., Vol. II, Philadelphia, [printed at Edinburgh.] 4to, xxiv and 1045 pp., 45 pl., 7 sect.
1858. *H. D. Rogers*, Final Rep., Atlas, 2 maps (5 sheets), 2 sections.

DELAWARE.

1839.* *Jas. C. Booth*, 1st and 2nd Ann. Rep., Dover, 8vo, 25 pp.
1841. " Final Rep., Dover, 8vo, 188 pp.

MARYLAND.

1834. *J. T. Ducatel* and *J. H. Alexander*, Rep. on Projected Survey, Annapolis, 8vo, 39 pp., map.
1834. *J. H. Alexander*, Rep. on New Map, Annapolis, 8vo, 12 pp., map.
1835.* " Rep. Annapolis, 8vo, 34 pp.
1837. " Rep. " 8vo, 44 pp.
1834. *J. T. Ducatel*, 1st Ann. Rep., Annapolis, 8vo, 44 pp.
1835.* " 2d Ann. Rep., " 8vo, 60 pp. Map and sections.
1836. *J. T. Ducatel*, 3d Ann. Rep., Annapolis, 8vo, 60 pp. Map and sections.
1837. *J. T. Ducatel*, 4th Ann. Rep., Annapolis, 8vo, 60 pp.
1838. " 5th " " 8vo, 33 pp., 4 pl.
1839.* " 6th " " 8vo, 49 pp.
1840. " 7th " " 8vo, 59 pp. 3 pl.
1860. *Philip T. Tyson*, 1st Bienn. Rep., Annapolis, 8vo, 145 and 20 pp., map.
1862. *P. T. Tyson*, 2d Bienn. Rep., Annapolis, 8vo, 92 pp.

VIRGINIA.

1836. *Wm. B. Rogers*, Rep. Geol. Reconn., Philadelphia, 8vo, 143 pp., section.
1838. *W. B. Rogers*, 1st and 2d Ann. Reps., Philad., 8vo, 87 pp.
1839. " 3d Ann. Rep., ——, 4to, 52 pp.
1840. " 4th " Richmond, 8vo, 161 pp.
1841. " 5th " " " 132 pp.

NORTH CAROLINA.

1824. *Denison Olmsted*, 1st Ann. Rep., "Part I," ——, 12mo, 84 pp.
1852. *E. Emmons*, " " Raleigh, 12mo, 181 pp.
1856. " Rep. on Midland Counties, New York and Raleigh, 8vo, 351 pp., 15 pl.
1858.* *E. Emmons*, Rep. Agric. Eastern Counties, New York and Raleigh, 8vo, 314 pp.

SOUTH CAROLINA.

1826.* *L. Vanuxem*, Rep. published in newspapers, and most of it in Mills' Statistics of S. C.
1843.* *Edmund Ruffin*, Agricultural Rep., with Appendix, Columbia, 8vo, 176 pp.
1844. *M. Tuomey*, 1st Ann. Rep., Columbia, 12mo, 63 pp. (including Suppl. to Ruffin's Rep.)

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1848. *M. Tuomey*, Final Rep., Columbia, small 4to, 293 and lvi pp., map.
1857. *Oscar M. Lieber*, 1st Ann. Rep., Columbia, 8vo, 136 pp., 9 pl.
1858. " 2d " " 8vo, 143 " 5 "
1859. " 3d " " 8vo, 223 " 3 "
1860.* " 4th " " 8vo, 194 " 4 "

ALABAMA.

1850. *M. Tuomey*, 1st Biennial Rep., Tuscaloosa, 8vo, xxxii and 176 pp.
1853.* " map. ——.
1856. " 2d Biennial Rep., Montgomery, 8vo, xix and 292 pp., map (edited by J. W. Mallet).

MISSISSIPPI.

1854. *B. L. C. Wailes*, 1st Rep., Jackson, 8vo, 371 pp.
1857. *L. Harper*, Prelim. Rep., Jackson, 8vo, 350 pp., 7 pl., map.
1858.* *Eug. W. Hilgard*, Ann. Rep., Geol. and Agric., Jackson, 12mo, 22 pp.
1860. * *E. W. Hilgard*, Rep. Geol. and Agric., Jackson, 8vo, 391 pp., map.

TENNESSEE.

1835. *G. Troost*, 3d Rep., Nashville, 12mo, 32 pp., map.
1837. " 4th " " " 37 pp. "
1840. " 5th " " 8vo, 75 pp. "
1841.* " 6th " " 12mo, 48 pp. "
1844.* " 7th " " 8vo, 45 pp. "
1845.* " 8th " " 12mo, 40 pp. "
1848. " 9th " " " 39 pp., 2 pl.
[Troost's 1st and 2d Reports were not published.]
1856. *Jas. M. Safford*, 1st Biennial Rep., Nashville, 8vo, 164 pp., map.
1857. " 2d " " " 11 pp.

KENTUCKY.

1839. *W. W. Mather*, Rep. of Geol. Reconn. (1838), Frankfort, 8vo, 40 pp.
1856. *David D. Owen*, 1st Rep., Frankfort, 8vo, 416 pp., 7 pl., 2 maps, 7 sections.
1857. *D. D. Owen*, 2d Rep., Frankfort, 8vo, 391 pp., Atlas of 10 pl., and 1 chart.
1857. *D. D. Owen*, 3d Rep., Frankfort, 8vo, 589 pp., Atlas of 10 pl., and 1 chart.
1861. *D. D. Owen*, 4th Rep., Frankfort, 8vo, 616 pp.

OHIO.

1836. *S. P. Hildreth*, Legislative Rep. on Survey, Columbus, 12mo, 18 pp. 2 sections.
1837. *John L. Riddell*, Legislat. Rep. on Survey, Columbus, 8vo, 34 pp.
1838. *W. W. Mather*, 1st Ann. Rep., Columbus, 8vo, 134 pp.
" " 2d " " 8vo, 286 "

INDIANA.

1838. *D. D. Owen*, 1st Rep., Indianapolis, 8vo ?, 34 pp.
1839. " 2d " " " 54 "

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1855.* *R. T. Brown*, Letter to Agric. Board, Indianapolis, 8vo, 30 pp.
1862. *D. D. Owen* and *Richard Owen*, Rep. Geol. Reconn., Indianapolis, 8vo, xvi and 368 pp., 11 pl.

ILLINOIS.

1853. *J. G. Norwood*, Rep. Prog., Springfield, 8vo, 13 pp.
1857. " " on Coals, Chicago, " 98 "
1866. *A. H. Worthen*, Rep. Geology, Vol. I, Springfield, large 8vo, 504 pp., with map and sections.

MICHIGAN.

1838. *Douglass Houghton*, 1st Rep., Detroit, small 8vo, 37 pp.
1839. " 2d " " " 39 and 123 pp.
1840.* " on Salt Springs, (House Doc. Vol. I, p. 18.)
" " 3d Ann. Rep., Detroit, 8vo, 124 pp.
1841. " 4th " " 184 "
" * " Rep. Progress of Maps, ——
1842.* " 5th Ann. Rep., ——
1861. *A. Winchell*, 1st Biennial Rep., Lansing, 12mo, 339 pp.
1846. *A. B. Gray*, Rep. to War Dept. on Mineral Lands, Lake Superior, Washington, 8vo, 23 pp., map.
1849. *Chas. T. Jackson*, Rep. (U. S.) on Mineral Lands, Washington, 8vo, 237 pp., 6 maps.
1849. *J. W. Foster* and *J. D. Whitney*, Rep. (U. S.) on Mineral Lands, Washington, 8vo, 330 pp., 9 maps, 7 pl.
1849. *Wm. A. Burt*, Rep. (U. S.) Mineral lands L. Superior, Washington, 8vo, 63 pp.
" *Bela Hubbard*, Rep. (U. S.) Mineral lands L. Superior, Washington, 8vo, 76 pp.
1850. *J. W. Foster* and *J. D. Whitney*, Rep. (U. S.) Geol. L. Superior Land Dist., Part I, Washington, 8vo, 224 pp., 4 maps, 12 pl.
1851. *J. W. Foster* and *J. D. Whitney*, Rep. (U. S.) Geol. L. Superior Land Dist., Part II, Washington, 8vo, xvi and 406 pp., 35 pl.

WISCONSIN.

1854. *Edward Daniels*, 1st Ann. Rep., Madison, 12mo, 84 pp.
1855. *J. G. Percival*, " " " " 101 " map.
1856. " 2d " " " " 111 "
1858. *Edward Daniels*, " " " " 62 "
" " and others, " " " " 12 "
1860.* *J. Hall*, Ann. Rep. (for 1859), Madison, ——
1861. " " Madison, 12mo, 52 pp.
1862. *J. Hall* and *J. D. Whitney*, Final Rep., Vol. I, Albany, 8vo, 455 pp., 10 pl., 2 maps.

[To be concluded.]

9. *Human remains in Belgium.*—Mr. EDWARD DUPONT has presented to the Royal Academy of Brussels (June 30, 1866) a paper on his later researches in the caverns on the borders of the Lesse, near where it empties into the Meuse. He has examined two localities near Walsen, one

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of which was not known before, and he has had the good fortune to find there numerous bones which he has described in detail.

It is known that in a work upon the Quaternary deposits of the province of Namur the author of these researches has distinguished three stages, which he designates, respectively, (1) from the presence of the Mammoth (*Elephas primigenius*), (2) of the great Cave Bear (*Ursus spelæus*), and (3) of the Reindeer (*Cervus tarandus*). But up to the present time he had found but few traces of the fauna of the first two stages. The two caverns called the Hyena cave and the Naulette cave have given him numerous remains which have confirmed his first impressions. In the first of these caves, called the cave of the Hyena, because of the quantity of bones of the *Hyæna spelæa* which it contains, he found teeth of the cave bear (*Ursus spelæus*), of the *Elephas primigenius* (a milk tooth), also bones of the *Rhinoceros tichorinus*, horse, fox, reindeer, &c., nearly all bearing marked traces of the teeth of a strong Carnivore. All the extremities are gnawed and there are no traces of the epiphyses; a great number of splinters are also gnawed. The bones of the hyena, on the contrary, bear no such traces, and as this, moreover, is the only Carnivore he has found there, he is inclined to believe that this was a hyena cave, and that the bones of other animals found in the same bed are the remains of their repast. The results of the explorations of this cave Mr. Dupont considers very important in their bearing upon the Quaternary deposits. These excavations determine the exact place, in the series, of the great cave Mammifers. In fact, the debris of the principal animals which compose this fauna are found also in the sandy-argillaceous stratified beds of alluvium (or "lehm") of the country; they evidently existed immediately before the deposit of these beds. Moreover, these stratified beds of gritty clay are found in the caverns as well as in the Quaternary outside in the province of Namur, between the great deposit of rolled pebbles on one side, and the argillaceous pebble deposit on the other. But the deposit of the rolled pebbles in the valleys is eminently characterized by the remains of the *Elephas primigenius*, so that the beds have justly received their name from their presence. On the other hand the deposit of yellow clay containing pebbles, which accords exactly with the deposit called red alluvium in the Paris basin, includes in the caves the fauna of the reindeer properly so called, that remarkable fauna whose distinguishing feature is the absence of all extinct species, and the presence of a series of animals still in existence, but now banished to colder climates. The true cave fauna, characterized principally by the great Carnivores, which are at the present day wholly extinct, separates the two fauna. This accords with the ideas Mr. Dupont had before brought forward in his paper on the Quaternary division of the province of Namur.

In the second of these caverns, named La Naulette, Mr. Dupont has found, among other organic remains, a bone of the *Elephas primigenius*, and a human jaw with a human ulna. The antiquity of these last bones cannot be contested since they are covered by several beds of stalagmites between which Mr. Dupont has recognized his medium stage, and upon which rest the deposits of the reindeer age. On the other hand this jaw differs from those of all the races found in Europe at the present day, in

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its forward prolongation (prognathism), a characteristic which is apparent to a certain degree in a jaw bone found by Mr. de Vibraye in the grotto of Arcy, in Bourgogne, associated equally with the *Elephas primigenius* and the *Rhinoceros tichorinus;* this peculiarity has also been observed in nine other jaws collected together in a cavern called the Cave of Frontal, at Furfooz. Mr. Dupont's discovery of these human remains is confirmed by Mr. Dumon, chief engineer of bridges and causeways, Mr. Eugene Cœmans, Mr. John Jones, and Lord Talbot of Malahide, who visited the cavern at the precise moment that the jaw was found, and who were convinced of its association with the other remains. The human bones have also been submitted by him to Messrs. Van Beneden, Spring, Bruner-Bey, Lartet, de Quatrefages, Busk, and Carl Vogt.

Mr. Dupont has found associated with these human remains many bones which bear the trace of the hand of man. One is a fragment of bone which is probably from a Ruminant. This bone is pierced with a hole which is evidently artificial, for the edges show a surprising neatness of finish. Moreover, the edges of this fragment of bone bear marks which appear to have been made with a very sharp instrument. Some persons, among whom is Mr. Quatrefages, believe that it is evidence of some peculiar method of cracking. Many fragments of marrow bones present also indications of man analogous to what has been found in other caverns, the bones evidently having been broken by the hand of man.

Mr. Dupont closes his notice with some remarks upon the fauna concealed in the alluvium of the Hyena and Naulette caves. Although the presence of three animal species may be respectively the distinguishing feature of the three Quaternary stages indicated above, we must conclude from the facts gathered only that these stages correspond to the periods in which the species that they indicate had their principal development, and not that these species did not exist before, or after, the period. Although in this case the beds of rolled pebbles are characterized by the presence of the *Elephas primigenius*, it does not follow that this species occurs only in this deposit, for we find it with the *Elephas meridionalis* in the *Forest beds*, as has been established by Sir C. Lyell in his Antiquity of Man, p. 224, and it was still living in Belgium during the deposit of the stratified alluvial beds (lehm). The *Ursus spelæus* seems to present an analogous fact, since the deposit of rolled pebbles of the cave of Frontal has furnished a canine tooth that appears to belong to this species. The common stag, the brown bear, and chamois are also remarkable examples of the same fact. Finally the reindeer seems to have lived, after the age of the *Elephas meridionalis*, in more southern regions than those in which it is now found; it existed in our regions with the *Elephas primigenius*, *Rhinoceros tichorinus*, &c., but it never acquired there that great numerical development which permits us to regard it as characterizing by its remains a long geological epoch subsequent to the disappearance of these large Quaternary species.

The article continues with results of other observations of interest.—*L'Institut*, Nov. 21st, 1866.

10. *Hübnerite, a new mineral.*—E. Riotte has described, in the Reese River Reveille, a new tungstate of manganese, entirely free from iron,

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found in the Erie and Enterprise veins in Monmouth district, Nevada. From a notice of Riotte's paper by H. Credner,* we take the following. Crystallization trimetric, $I : I = 105°$; generally in columnar masses or foliated, imbedded in quartz. Cleavage brachydiagonal, very perfect. Fracture, uneven. H.=4·5. G.=7·9. Color brownish-red to brownish-black. Streak yellowish-brown. Luster adamantine on the cleavage plane, and otherwise greasy. Translucent to opaque. Analysis by Riotte and Hübner gave, WO_3 76·4, MnO 23·4. BB. gives reactions for both tungstic acid and manganese. Partially soluble in chlorhydric acid leaving a yellow residue almost completely soluble in ammonia. Hübnerite is, according to Dr. Adelberg, found in both of the localities in a vein three to four feet wide in a metamorphic clay-slate, and is associated with scheelite, fluor-spar and apatite. A later article† by Breithaupt questions the correctness of the crystallographic measurements, and gives the density as 7·14.

11. *Mineralogical Notices;* by Wm. P. Blake.‡—*Kerargyrite.* Chlorid of silver occurs in thin crusts on gold-bearing quartz in the Morgan gold mine, Carson Hill, Calaveras county. This vein is in the main gold belt, and is regarded as a part of the chief gold vein of the state. It is noted for the massive specimens of vein gold which it affords. The association of chlorid of silver with the gold is novel, and has not been before observed by myself or others to my knowledge. A little galena occurs in the same vein, and in another part of it, gray copper ore, probably argentiferous, occurs sparingly and may be the source of the chlorid of silver. The crusts are about the thickness of an ordinary visiting card, and when freshly cut or scraped have a delicate pearl-gray color, which speedily changes to purple in the sunlight.

This species is also found in remarkably fine specimens in the Poorman lode,§ Idaho, associated with proustite, native silver, and native gold. Sheets of the chlorid are taken out of the soft clay of the vein, and are from one-eighth to one-quarter of an inch in thickness. It is also found in irregular massive aggregations of crystals, in cubes, without any modification, and over an eighth of an inch square. The color of my specimens is brown, passing into violet-blue in some portions.

Proustite.—The "ruby silver" which occurs with the chlorid in the Poorman lode, as above, is often in masses of several ounces, or even pounds, in weight, and it is reported to be occasionally seen in beautiful crystals, but none have yet come under my observation.

Copper-glance, Red oxyd of Copper, Native Copper.—These species are found together in the Red Cap claim, Klamath county, Cal., in serpentine. The metallic copper is seen in points throughout the massive sulphuret, and is sometimes enveloped in red oxyd. Both the copper and the oxyd are most abundant near the surface of the masses of ore, and they are apparently formed by the gradual decomposition of the sulphurets.

* Berg. und Hüttenmännisches Zeitung, xxiv, 370. † Ibid., xxv, 157.

‡ A portion of this paper was read before the California Acad. Nat. Sci., Oct. 15th, 1866, and another portion bears the date of Nov. 17th.

§ Specimens from this well-known locality are contained in many of the collections in the east.—G. J. B.

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Danaite.—A cobaltic variety of mispickel is found associated with iron and copper pyrites at Meadow Lake, Nevada Co., Cal. It is in distinct, well formed, brilliant crystals of a tin-white color, and about a quarter of an inch in diameter. They are modified nearly as in fig. 289, Dana's Mineralogy. This mineral gives cobalt reactions before the blowpipe, and appears to contain a large percentage of this metal. The ore is said to contain nickel also, and is being mined for shipment.

Cinnabar in calcite.—Cinnabar of a beautiful vermilion color is found in Idaho abundantly spread through a gangue of massive compact limestone or marble. No quartz or other minerals are visible in the specimens.

Wulfenite.—Molybdate of lead occurs in the argentiferous lead ores of the Empire mine, Inyo Co., Cal. It is in crusts and seams about one-eighth of an inch thick, and is associated with galena, cerusite, malachite, and chrysocolla. The contrast of the brilliant yellow color of this species with the masses of green silicate of copper renders these specimens very beautiful and desirable for cabinets.

Sulphuret of silver.—This mineral is found in ragged masses matted with quartz crystals, and associated with free gold, in the "Silver Sprout" vein, Kearsarge District, Sierra Nevada.

*Tungstate of manganese.**—I have received from Mr. Ewer, fragments of a mineral from Nevada, which appears to be tungstate of manganese. It is in radiating prismatic crystals; color dark olive-green; high specific gravity, and before the blowpipe gives the reactions of tungstic acid and of manganese.

Specular iron.—Mr. Bennett of Durango, Mexico, has sent me some interesting crystallizations of specular iron ore, associated with oxyd of tin, from the tin washings of that place.

Tetrahedrite, galena, cerusite, pyromorphite, blende, with a little *red copper ore* occur together in the Chicago claim, Shasta county, Cal. The ore is rich in silver.

III. BOTANY.

1. *The Miscellaneous Botanical works of* Robert Brown, Esq., D.C.L., F.R.S., Foreign Associate of the Academy of Sciences of the Institute of France. Vol. I, containing 1, *Geographico-Botanical*, and 2, *Structural and Physiological Memoirs.* London: Published for the Ray Society by Robert Hardwicke, 192, Piccadilly. 1866. 8vo.—It was well determined by the Ray Society to collect and reprint Mr. Brown's published papers, originally scattered through various volumes, many of them little accessible. And Mr. Bennett, his intimate associate, and his successor at the British Museum, was the only proper editor. He has added to this volume a full and elaborate index,—a great boon to botanists,—also the following brief Preface:—

"The present volume contains the first portion of the works of the distinguished author, now for the first time collected in England, and reprinted from the originals, without change, in accordance with his express desire. It had been his intention to reprint them himself with annotations; but, unfortunately for science, this intention was never carried out, and it remained for the editor simply to superintend a verbatim reprint.

* This mineral is apparently Hübnerite, noticed on a previous page.—G. J. B.

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"The memoirs are arranged in three divisions,—1st, Geographico-Botanical; 2d, Structural and Physiological; 3d, Systematic. Of course this arrangement is in some degree arbitrary, inasmuch as observations relating to both of the other divisions are continually occurring in the memoirs referred to each of them; but on the whole it has appeared to be the most convenient for reference. The present volume contains the first two of these divisions; the second will be devoted to Systematic Memoirs and Miscellaneous Descriptions of Plants; and a separate volume in large 4to, will contain the illustrative figures to both."

The memoirs are arranged according to date. The first volume consequently begins with the "*General Remarks on the Botany of Terra Australis*," in Flinders' Voyage, 1814; and ends with "*Some Account of Triplosporite, an undescribed Fossil Fruit*, 1851. The fruit is now pretty well determined to be that of *Lepidostrobus*. The most important of Mr. Brown's writings are therefore comprised in this volume, and the study of and reference to their rich and varied contents is immensely facilitated by the admirable index prepared, upon which the editor has evidently bestowed great labor and care. A. G.

2. *Nature of Anthers, &c.*—J. Mueller, the elaborator of the *Euphorbiaceæ* for DeCandolle's Prodromus, has published three brief papers in the Mémoires de la Société de Phys. et d'Hist. Nat. de Geneve, upon points relative to the anther which fell under his observation in the progress of his work. The first is a case in which the anther had reverted to a leaf, giving evidence that this organ is homologous with a plane lamina, its margins or line of dehiscence answering to the margins of a leaf. The second is upon the trilocular anther of *Pachystemon*, neatly showing that this (and by just analogy the three-celled anther of *Ayenia* also) is not a combination, but answers to a single leaf. The third exhibits the double flexure in the bud, of the apex of the filament in *Cephalocroton*, the anther remaining upright, as contrasted with the inverted anthers of *Croton*. This reminds us to take some notice of—

3. *An Innovation in Nomenclature in the recently issued volume of the Prodromus.* Take, for example, the genus *Cephalocroton*, established by Hochstetter, in 1841. It appears that Baillou had reduced to it two or three species upon which he had formerly constituted two other genera; and now Dr. Müller gives the genus as "*Cephalocroton* Baillon." Take next the genus *Ricinocarpus*, established by Desfontaines and adopted by the early monographer of the order, Adrien Jussieu. It happens that the *original* of the genus has been published by Sprengel under the name of *Rœperia*, and named also by Sieber *Echinosphæra*. Is it for adding these two names as synonyms that the *Prodromus* writes "*Ricinocarpus* Müll. Arg."? Evidently not, as these synonyms are given by Endlicher. Is it because of two species now first described, of which the author constitutes two new sections of the genus, the rest of the species constituting *Euricinocarpus*? No other reason is apparent. But here no one, not the author himself, ever regarded these two new plants as anything else than species of *Ricinocarpus*, that is to say, of Desfontaines' genus.

Again, Adrien Jussieu dedicated to his friend Ampere a genus of a single known species: Brongniart added a second species: Dr. Müller

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has now added a third, and, forming for it a separate section, has taken the genus as his own! These are fair illustrations of the plan pursued throughout the volume. The principle acted on appears to be, that whenever an author revises a genus and extends its limits, or adds any species which are not wholly homogeneous with the old ones, although in his opinion they belong to it, he may supersede the name of the founder of the genus by his own.

We suppose the rule would hold as well in case of the restriction, as of the amplification of a genus. Upon this principle how many genera would be left to Linnæus? Not *Berberis*, for it would be attributed to the botanist who first remanded the pinnate species which composed Nuttall's genus *Mahonia*. Not even *Podophyllum*, for the second species, being hexandrous, brings in an important modification of the generic character. But the volume under consideration itself exemplifies the inevitable result. Out of the seventeen admitted Linnæan or ante-Linnæan genera it comprises, nine have lost the name of the founder. Half of the eight which retain it have only from one to six species each; and most of the rest, viz., *Stillingia*, *Omphalea*, *Manihot*, and *Andrachne*, have escaped apparently through some variation of the rule, or laxity in its enforcement, the grounds of which are not clearly obvious.

The same treatment is, naturally enough, applied to species. Take a single example from those presented on almost every page of the volume. Linnæus reduced all the forms of Castor-oil plant he knew to *Ricinus communis* L. Dr. Müller does the same: but he knows many more forms, and has arranged them with exhaustive particularity under four primary divisions, sixteen varieties, and some of these into almost as many sub-varieties. So this equivalent conclusion, resulting from a survey of more materials, is represented not by *R. communis* L., but by *R. communis* Müll. Arg. Now who shall decide upon the quantity of materials to be revised, or number of synonyms to be reduced, which may entitle a writer to take this great liberty? The only case which might seem to warrant it, is when two or more species of the same author and the same date are comprehended in one under a general character. Instances of the sort are probably to be met with in the work under consideration. But *Mercurialis annua*—from which the name of Linnæus has dropped—is not a case in point, *M. ambigua* (regarded as a mere state of the former) having been published by the younger Linnæus.

Finally, there is a foot-note on p. 192, which should not pass unnoticed. For the statement, "Nomina non rite edita sunt nomina inania omnique prioritate carentia," as interpreted by the use made of it upon the occasion of the note, opens the way by which a just and well-established rule is made to operate in violation of the prevalent comity of botanists. Our own remarks upon this very point, in this Journal for March, 1864, p. 279, have been once or twice reprinted in Europe, without dissent; and we see no good reason as yet for recalling them. While the rule in regard to priority has its proper scope in maintaining that "manuscript names in collections, however public, should assert no claim as against properly published names," still, "the distribution of named specimens [and, *à fortiori*, of these in sets, widely distributed among herbaria, as were Sieber's], where and as far as they go, is held to be tan-

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tamount to publication." So of names and original observations attached to specimens in herbaria. These names are always attached antecedently to publication; and a monographer, having, as he should, free access to all herbaria within his reach, might work a deal of harm if he did not regard such names as *to him* all the same as if already published. The full recognition of an obligation to do this has sensibly quickened the advance of botany, by securing the early distribution of materials which might otherwise have been long withheld, and by widely opening herbaria to all competent working botanists, and especially to monographers, who should be the last to deprecate the system. No doubt, like other good and necessary things, it is open to abuse and may now and then work some hardship. We would only remark that, whether on the whole the custom be good or bad, it is one for the introduction and maintenance of which we are indebted to no single botanist so much as to the founder of the Prodromus. And he, of all others, would be most surprised to learn that *Leptocaulis echinatus*, &c., *Trepocarpus Æthusæ*, and *Eulophus Americanus*, were Candollian and not Nuttallian genera and species.

Upon the whole subject we would remark, in brief, that it can hardly be supposed that these innovations will pass unquestioned; that no living botanist now stands in such position that he can becomingly set aside *mero motu* recognized usages in nomenclature; that the closing volumes of the Prodromus, which for forty years has been most efficient in establishing these usages, is hardly the proper place for changing them; and that, finally, a Botanical Congress, such as that over which, last spring, the distinguished editor of the Prodromus so happily presided, would have been a proper body to consult upon subjects of such delicacy and general interest. A. G.

4. *Mémoire sur la Famille des Pipéracées*, par M. Casimir DeCandolle. 4to pamph., pp. 32, and with 7 plates. (Extr. from *Mém. Soc. Phys. and d'Hist. Nat. Genève*, XVIII, 1866.)—The younger DeCandolle, having elaborated for the Prodromus the order *Piperaceæ*, has consigned the more interesting results of his study of the anatomy and general structure of these peculiar plants to the present article, in which, also, he indicates the grounds upon which he has reduced all the proposed piperaceous genera to three. The structural and histological details are full of interest, especially what relates to the wood of the stem; but we must defer an abstract, perhaps until that portion of the Prodromus is issued. A. G.

5. *American Heather.*—The question, whether *Calluna* is or is not indigenous to the New World,—which during several years past has been repeatedly referred to in this Journal, as additional facts came to our notice,—has now taken a new turn, Dr. Seemann, in his Journal of Botany for October last, having published and neatly figured "the Newfoundland Heather" as a distinct species, *Calluna Atlantica*. He founds it upon specimens originally from Newfoundland, which have been for some years cultivated by Dr. Moore in the Glasnevin Gardens, Dublin, side by side with the common European Heather. The diagnosis attempted, Dr. Seemann admits to be as yet far from satisfactory, except as to a biological distinction observed by Dr. Moore, viz., "that whilst the Newfoundland one always suffered from frost, and turned brown during the

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mild Irish winter, the common British form, growing by its side, was unaffected by cold and retained its usual green color." Although "no argument can possibly set aside" this fact, yet its value as a character has to be considered. Probably in the station from which these specimens were lately transferred, as well as in Iceland and the higher Alps, whence Dr. Seemann has the same form, the plant was accustomed to complete protection by snow from changes of temperature the whole winter through. Unfortunately we have no specimens from Newfoundland, and Dr. Seemann does not speak of the Cape Breton, Nova Scotian or New England plants. Upon examination of these, we do not find that the indicated differences in structure (mainly the naked pedicels, broader sepals, and tip of flowering branches not continued into a leafy shoot while the flowering lasts) coincide or hold out. So that as yet a second species can hardly be said to be established. A. G.

IV. ASTRONOMY.

1. *Observations of Venus near its inferior Conjunction.*—With the excellent Equatorial of the Sheffield Scientific School, made by Clark & Sons, and having 9 inches clear aperture, Venus was carefully observed, in close proximity to the Sun, both before and after her late inferior conjunction, which happened on the 11th of December. At her nearest approach ($9^h\ 52^m$ A.M.), the planet was only 22′ from the Sun's northern limb, and had the conjunction occurred a day earlier, there would have been a transit.

On the 10th, the planet was seen and measured, at $3^h\ 30^m$ P.M., when only 1° 8′ from the Sun's limb, and might have been observed later, but for the risk to the eyes, (already severely tried,) from the strong sunlight, which could not well be shut off from the telescope.

On the day of conjunction, no attempt was made to find the planet. On the day following, (the 12th.) it was again seen, at $11^h\ 30^m$ A. M., being then about 1° 36′ from the Sun's limb.

Some days before the conjunction, it was apparent that the crescent formed more than a semicircle—on the 7th, full 40° more by measurement. On the 10th, it formed a *complete circle*—bright, thin and delicate (the crescent proper), on the side toward the Sun, but on the opposite side, a mere faint line of light, very difficult to be seen, on account of the strong light in the field, and the atmospheric disturbance. Yet, by glimpses, it was distinctly perceived as a ring, by several observers, and constantly as more than three-fourths of a circle.

The appearances were similar, though perhaps a little better seen, on the 12th, the day after the conjunction. Yet, the planet was then only half a degree farther from the Sun, and the full ring could be made out only in the more favorable moments with respect to light and atmosphere—particularly, when the light, both of the sun and of the planet, was partially cut off from the object glass, by the shutter of the observatory. Such a compromise between sun-light and planet-light gave generally the best views, except twice, about noon, when, fortunately, a passing cloud left the planet in sight for a few seconds, while yet the Sun was obscured. The background was then comparatively dark, and the

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thread of light around the limb opposite to the sun perfectly distinct and complete. The northern portion of the crescent proper, however, did not diminish uniformly in brightness, or apparent thickness, toward the cusp, but a considerable space, between 25 and 50 degrees from the vertex to the left, by estimate, was very perceptibly fainter than a like portion of the circumference next beyond toward the right, whence it gradually narrowed to the mere faint line of light before mentioned. These observations were made between half past 11 and half past 1 o'clock.

At 2^h 15^m P. M., the planet was readily found with a portable 5 foot Clark telescope of $4\frac{3}{8}$ inches aperture, by taking a position in the shadow of a chimney some 50 or 60 feet distant. The complete ring, and the faint portion of the crescent proper, just described, were both distinctly seen—better, in fact, than with the equatorial, except in the cases mentioned, when the sun was intercepted by a passing cloud.

Observations were prevented on the 13th. On the 14th, at noon, the visible cusps extended full 50° beyond a semicircle, but no irregularity in brightness was noticed, as on the 12th. On the 15th, the cusps had receded to 30°, and on the 18th, to 22°, beyond a semicircle.

These observations have a direct and obvious bearing upon the question of the atmosphere of Venus.

The powers used were from 80 to 200 on the Equatorial, and 90 on the smaller telescope.

For the measurements, a position-micrometer by Dollond was employed. C. S. L.

Sheffield Scientific School, Dec. 29, 1866.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Telegraphic Determination of Longitude between Europe and America.*—Our readers will be gratified to learn that the undertaking of measuring the longitude between the Observatory at Greenwich England, at the stations of the geodetic survey of the United States, by means of the Atlantic cable and the connecting Telegraph lines, has been successfully accomplished, under the auspices of the United States coast survey. We are informed that the preliminary computations, such as could be made during the progress of the work exhibit an unexpectedly close agreement of results. The signals transmitted by the cable possess far greater sharpness than was anticipated, and the time of transmission has been found remarkably constant. By the liberality of the Anglo-American Telegraph Company the use of both cables was freely tendered for the transmission of signals and experiments on transmission Time. The Astronomer Royal gave his co-operation in connecting the European terminus of the cable with Greenwich, and every facility was afforded by the officers of the American and Provincial telegraph lines, in a truly liberal spirit. An interesting account of the operations may be looked for at the January meeting of the National Academy of Sciences, by Dr. B. A. Gould, under whose direction the work has been executed and who occupied the terminus in Ireland. J. E. H.

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2. *Mr. George Peabody's recent gifts to Science.*—The last number of this Journal contained an announcement of Mr. Peabody's gift of $150,000 to Harvard College, for the establishment of a museum of American Archæology, and Ethnology, and the same amount to Yale College for a museum of Natural History. His donations to these institutions were accompanied by the following statements of his wishes in regard to the disposition of the fund.

GIFT TO HARVARD COLLEGE.

Georgetown, October 8, 1866.

To the Hon. ROBERT C. WINTHROP, His Excellency CHARLES FRANCIS ADAMS, FRANCIS PEABODY, STEPHEN SALISBURY, ASA GRAY, JEFFRIES WYMAN, and GEORGE PEABODY RUSSELL, Esqrs.

Gentlemen,—Accompanying this letter I enclose an instrument giving to you one hundred and fifty thousand dollars ($150,000) in trust for the foundation and maintenance of a Museum and Professorship of American Archæology and Ethnology in connection with Harvard University.

I have for some years had the purpose of contributing, as I might find opportunity, to extend the usefulness of the honored and ancient university of our Commonwealth, and I trust that in view of the importance and national character of the proposed department and its interesting relations to kindred investigations in other countries, the means I have chosen may prove acceptable.

On learning of your acceptance of the trust, and of the assent of the President and Fellows of Harvard College to its terms, I shall be prepared to pay over to you the sum I have named.

Aside from the provisions of the instrument of gift, I leave in your hands the details and management of the trust; only suggesting, that in view of the gradual obliteration or destruction of the works and remains of the ancient races of this continent, the labor of exploration and collection be commenced at as early a day as practicable; and also that in the event of the discovery in America of human remains or implements of an earlier geological period than the present, especial attention be given to their study and their comparison with those found in other countries.

With the hope that the Museum, as thus established and maintained, may be instrumental in promoting and extending its department of science, and with fullest confidence that under your care the best means will be adopted to secure the end desired,

I am, with great respect, your humble servant,

GEORGE PEABODY.

I do hereby give to Robert C. Winthrop of Boston, Charles Francis Adams of Quincy, Francis Peabody of Salem, Stephen Salisbury of Worcester, Asa Gray of Cambridge, Jeffries Wyman of Cambridge, and George Peabody Russell of Salem, all of Massachusetts, the sum of one hundred and fifty thousand dollars, to be by them, and their successors, held in trust to found and maintain a Museum of American Archæology and Ethnology, in connection with Harvard University, in the city of Cambridge, and Commonwealth of Massachusetts.

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Of this sum I direct that my said trustees shall invest forty-five thousand dollars as a fund, the income of which shall be applied to forming and preserving collections of antiquities, and objects relating to the early races of the American Continent, or such (including such books and works as may form a good working library for the departments of science indicated) as shall be requisite for the investigation and illustration of Archæology and Ethnology in general, in main and special reference, however, to the Aboriginal American races.

I direct that the income of the further sum of forty-five thousand dollars shall be applied by my said trustees to the establishment and maintenance of a Professorship of American Archæology and Ethnology in Harvard University; said professor shall be appointed by the President and Fellows of Harvard College, with the concurrence of the overseers, in the same manner as other professors are appointed, but upon the nomination of the founder or the board of trustees. He shall have charge of the above-mentioned collections, and shall deliver one or more courses of lectures annually, under the direction of the government of the university, on subjects connected with said departments of science.

Until this professorship is filled, or during the time it may be vacant, the income from the fund appropriated to it shall be devoted to the care and increase of the collections.

I further direct that the remaining sum of sixty thousand dollars be invested and accumulated as a Building Fund, until it shall amount to at least one hundred thousand dollars, when it may be employed in the erection of a suitable fire-proof museum building, upon land to be given for that purpose, free of cost or rental, by the president and fellows of Harvard College, the building when completed, to become the property of the college, for the uses of this trust, and none other.

The board of trustees I have thus constituted shall always be composed of seven persons, and it is my wish that the office of chairman be filled by Mr. Winthrop,—in the event of his death or resignation, by Mr. Adams, and so successively in the order I have named above. The trustees shall keep a record of their doings and shall annually prepare a report setting forth the condition of the trust and funds, and the amount of income received and paid out by them, during the previous year. This report, signed by the trustees, shall be presented to the president and fellows of the college.

In the event of the death or resignation of Mr. Winthrop, I direct that the vacancy in the number of the board be filled by the president of the Massachusetts Historical Society, who *ex officio* shall forever after be a member of the board. In the event of the death or resignation of Mr. Peabody, the vacancy to be filled by the president of the scientific body now established in the city of Salem, under the name of the Essex Institute; of Mr. Salisbury, by the president of the American Antiquarian Society; of Prof. Gray, by the president of the American Academy of Arts and Sciences; and of Prof. Wyman, by the president of the Boston Society of Natural History, all of whom shall forever after be *ex officio* members of the board.

Should the president of either of the societies I have named decline to act as a trustee, such vacancy, and all other vacancies that may occur

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in the number of the trustees, shall be filled by the remaining trustees, who shall, within a reasonable time, make the appointment or appointments.

I give to my said trustees the liberty to obtain from the Legislature an act of incorporation if they deem it desirable, to make all necessary by-laws, to appoint a treasurer, and to enter into any arrangements and agreements with the government of Harvard College, not inconsistent with the terms of this trust, which may, in their opinion, be expedient.

(Signed) GEORGE PEABODY.

Georgetown, Oct. 8, 1866.

GIFT TO YALE COLLEGE.

New York, Oct. 22, 1866.

To Professor JAMES D. DANA, Hon. JAMES DIXON, Hon. ROBERT C. WINTHROP, Professor BENJAMIN SILLIMAN, Professor GEORGE J. BRUSH, Professor OTHNIEL C. MARSH, and GEORGE PEABODY WETMORE, Esq.

Gentlemen,—With this letter I enclose an instrument giving to you one hundred and fifty thousand dollars ($150,000) in trust for the foundation and maintenance of a Museum of Natural History, especially of the departments Zoology, Geology and Mineralogy, in connection with Yale College.

I some years ago expressed my intention of making a donation to this distinguished institution, and convinced as I am of the importance of the natural sciences, and of the increasing interest taken in their study, it now affords me great pleasure to aid in advancing these departments of knowledge.

The rapid advance which natural science is now making renders it necessary to provide for the future wants of such a museum, as well as its present requirements, and I trust that the portion of the fund designed for this purpose will be found sufficient.

On learning of your acceptance of this trust, and of the assent of the President and Fellows of Yale College to its conditions, I shall be prepared to pay over to you the sum I have named, and I may then have some additional suggestions to make in regard to the general management of the trust.

Confident that under your direction this trust will be faithfully and successfully administered,

I am, with great respect, your obedient servant,

GEORGE PEABODY.

I hereby give to James Dwight Dana, of New Haven, Conn.; James Dixon, of Hartford, Conn.; Robert C. Winthrop, of Boston, Mass.; Benjamin Silliman, of New Haven, Conn.; George Jarvis Brush, of New Haven, Conn.; Othniel Charles Marsh, of New Haven, Conn.; and George Peabody Wetmore, of Newport, R. I., on his attaining his majority, the sum of one hundred and fifty thousand dollars, to be by them or their successors held in trust to found and maintain a *Museum of Natural History*, especially of the departments of Zoology, Geology and Mineralogy, in connection with Yale College, in the City of New Haven, State of Connecticut.

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Of this sum I direct that my said trustees devote a part, not to exceed one hundred thousand dollars, to the erection, upon land to be given for that purpose, free of cost or rental, by the President and Fellows of Yale College, in New Haven, of a fire-proof museum building, adapted to the present requirements of these three departments of science, but planned with especial reference to its subsequent enlargement, the building, when completed, to become the property of said college for the uses of this trust, and none other.

I further direct that the sum of twenty thousand dollars be invested, and accumulate as a building fund until it shall amount to at least one hundred thousand dollars, when it may be employed by my said trustees, or their successors, in the erection of one or more additions to the museum building, or in its final completion; the land for the same also to be provided free of cost or rental by the President and Fellows of Yale College, in New Haven, and the entire structure when completed to be the property of Yale College, for the uses of this trust and none other.

I further direct that thirty thousand dollars, the remaining portion of this donation, be invested, and the income from it be expended by my said trustees, or their successors, for the care of the museum, increase of its collections and general interests of the departments of science already named; the part of the income remaining after providing for the general care of the museum to be apportioned in the following manner; three-sevenths to zoology, three-sevenths to geology, and one-seventh to mineralogy; the said collections, as well as the museum building, to be exclusively for the benefit of the various departments of said College.

The Board of Trustees I have thus constituted shall always be composed of seven persons, of whom not more than four shall at any one time be members of the Faculty of Yale College. They shall have the general management of the museum, keep a record of their doings, and annually prepare a report setting forth the condition of the trust and funds, and the amount of income received and paid out by them during the previous year. This report, signed by the trustees, shall be presented to the President and Fellows of Yale College, in New Haven, at their annual summer session, and be by them filed in the archives of said college.

In the event of the death or resignation of either of my said trustees, I direct that his successor be the Governor of Connecticut, who, *ex officio*, shall forever after be a member of the Board. Any other vacancy that may occur in the Board of Trustees, either by resignation or by death, shall be filled by the remaining trustees within a reasonable time after such vacancy shall have occurred.

I give to my said trustees, and their successors, the liberty to appoint a treasurer, and to enter into any agreements with the President and Fellows of Yale College, not inconsistent with the terms of this trust, which may in their opinion be expedient.

(Signed,) GEORGE PEABODY.

New York, Oct. 22, 1866.

In addition to the above donations Mr. Peabody has recently given $500,000 to the Peabody Institute established by him at Baltimore, making its present endowment $1,000,000; and has increased to $250,000

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his previous gift to the Peabody Institute in his native town of Danvers, Mass. Each of these institutions will contain an extensive library, and annually provide several courses of free lectures on scientific and literary subjects. Mr. Peabody has, moreover, just made a donation of $25,000 to Phillips Academy, Andover, Mass., to provide instruction in the natural sciences and mathematics, and another of the same amount to Kenyon College, Ohio, for a similar purpose. He has also recently given $20,000 to the library fund of the Maryland Historical Society, and founded free libraries at Georgetown, Mass., and Thetford, Vt.

These munificent gifts, amounting in all to nearly $1,650,000, place the donor, already so highly honored for his other noble charities, among the foremost benefactors of science, and cannot fail to exert a most beneficial influence upon the educational interests of this country.

OBITUARY.

George W. Featherstonhaugh, the author of a geological report on the Missouri and Red rivers, published by our government, in 1834, and originator and editor of Featherstonhaugh's Geological Journal published in 1831, 1832 at Philadelphia, died at Havre on Sept. 28, in his eightieth year. He had been consul at Havre for nearly twenty years.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Geological Map of the Department of the Seine*, by Mr. Delesse. —This elaborate and beautiful Chart, the publication of which was announced in the last number of this Journal (p. 440), is worthy of a careful examination by all who are interested in the construction of maps of this kind, or in the geology of the region it embraces. It is constructed on a scale of 1 : 25000, and the method employed by Delesse is essentially the same as that used in his map of the city of Paris. The various formations, with exception of the diluvium, which is supposed to be removed, are represented by colors as in ordinary geological maps. In addition to this a new feature is introduced, which will doubtless be often employed in the future, and hence deserves more than a passing notice. By means of a system of horizontal curves, drawn at a perpendicular distances of 20 meters from each other, measured from the level of the sea, a subterranean geological map, or rather a series of maps, is formed on which the surfaces of the principal formations for each level is indicated. To obtain these curves Mr. Delesse examined all the various localities, where it was possible to make a geological section,—especially the quarries, wells, and other surface excavations, as well as the numerous subterranean works, executed within the last few years in the environs of Paris. Starting from data thus obtained, the elevation of the points, where a geological section was made, was accurately determined by leveling, and the operation repeated until a system of points was obtained sufficiently near together to admit of the tracing of horizontal curves indicating each surface. In this manner is represented the upper surface of the Cretaceous, the Plastic Clay, the White marls above the Calcaire grossier, the Travertin of St. Ouen, the Green clays, the Sandstone of Fontainebleau, and finally the under surface of the Diluvium. The intervening formations are, of course, also indicated by the same curves.

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By the aid of this subterranean geological map, it is easy to determine the strata which would be struck at any given point in the vicinity of Paris; for the colors indicate the formation lying immediately under the diluvium, and, as the point selected will fall between two horizontal curves representing the surfaces of the different strata, a fourth proportional is all that is required to calculate the depth at which any one of these surfaces may be reached.

The method employed in the execution of the map facilitates, moreover, a thorough study of the formations represented, and may be advantageously used in exploring for deposits of economic value. The chart has other features of interest which will repay examination. It is probably the most elaborate geological map ever constructed, and will doubtless long be regarded as a model. O. C. M.

2. *The American Naturalist, a Popular Magazine of Natural History.*—Under this title, the Officers of the Essex Institute, Salem, Mass., propose to publish a monthly magazine, commencing early in the present year.

The object of this journal is to supply a long-existing demand for a popular illustrated magazine of Natural History, devoted to the exposition of scientific topics in a free and familiar manner, without those technicalities which often render the mass of such reading tedious and difficult.

Among the contents of the magazine, will be papers on topics of a general and special nature relating to Natural History, illustrated with appropriate wood engravings, and occasional lithographic plates; these papers will be mainly original, but compilations and translations of papers from other sources will be introduced when deemed of sufficient interest. It will also contain accounts of excursions and expeditions made for scientific purposes, with descriptions of the various objects of interest discovered—explanations of the principles of the structure, development and classification of Animals and Plants, both living and fossil, and notices of recent discoveries in Geology and Archæology—directions for collecting, preparing and arranging collections, including descriptions of the latest methods of mounting and preparing specimens—short reviews of scientific and popular works on Natural History—brief notices of the meetings of the Natural History Societies throughout the country—descriptions of scientific museums, and answers to correspondents on scientific topics.

Each number will contain 48 octavo pages of reading matter, besides advertising sheets.

Such a magazine is greatly needed in this country and will doubtless meet the patronage to which its able corps of editors and imposing list of contributors entitle it.

The editors are A. S. Packard, Jr., M.D., in connection with E. S. Morse, Alpheus Hyatt and F. W. Putnam. V.

3. *A Manual of Blowpipe Analysis and Determinative Mineralogy;* by William Elderhorst, M.D. Third edition, 12mo, pp. 179, revised and greatly enlarged. Philadelphia, 1866. (T. Ellwood Zell.)—The value of this useful manual on blowpipe analysis has already been recognized in this Journal in noticing the second edition. But we have failed to discover evidence of the revision and enlargement announced on the title page of the third edition.

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4. *Catalogue of the Silurian Fossils of Anticosti, with descriptions of new genera and species;* by E. BILLINGS, F.G.S. 94 pp., large 8vo. Montreal, 1866. From the Geological Survey of Canada, Sir W. E. Logan, Director.—This report on the fossils of Anticosti, by the accomplished paleontologist of the geological survey of Canada, is more than a mere catalogue, as it contains descriptions of many species, with a number of wood-cuts. We defer a further notice to another number.

5. *Lessons in Elementary Chemistry;* by HENRY E. ROSCOE, B.A., F.R.S., Professor of Chemistry in Owens College, Manchester. London, Macmillan & Co., 1866. 18mo, pp. viii, 398.—This book of Dr. Roscoe's, though designedly an elementary work, is written from an advanced standpoint, and, while simple and clear in its statements, it carries the student fully up to the position which the science of chemistry has now reached. Adopting the unitary system in its completeness, it spends but little time in prefatory explanations, but leaves the philosophy to be gathered from the several substances considered. We notice several chapters of great value: especially those on the physical properties of gases; on the atomicity of the elements; on crystallography; on spectrum analysis, and solar and stellar chemistry; and his chapters introductory to organic chemistry. Questions upon the sections, with exercises are given in an appendix. We are glad to see he has abolished the unsatisfactory term "anhydride" and substituted "oxide" instead: the nitr.oxygen series being "nitrous oxide, nitric oxide, nitric trioxide, nitric tetroxide, and nitric pentoxide." His "potassium oxide" seems to us less smooth than the "potassic oxide" of Williamson; and "hydric-potassium sulphate" is improved if written hydro-potassic sulphate. We commend this little volume as one of the best elementary treatises on chemistry in the English language. G. F. B.

6. *Lecture notes for Chemical Students: embracing Mineral and Organic Chemistry;* by EDWARD FRANKLAND, F.R.S., For. Sec. C. S., Professor of Chemistry in the Royal Institution of Great Britain, etc. London, John Van Voorst, Paternoster Row, 1866. 12mo, pp. xx, 422.—Dr. Frankland's views upon the constitution of chemical compounds are well known through his published papers. "Organic as well as inorganic compounds are most instructively represented upon the typical compounds of the most polyatomic radical they contain." Thus upon the types $SbCl_3$* and $SbCl_5$ all the compounds of antimony may be written: as $SbEt_3$ and $SbEt_4I$. And CEtI, allylic iodid, and CMe_2H_2, propylic hydrid, are formed upon the carbon types CO and CO_2. Here it is evident that the composition of these compounds is determined by the equivalence of the highest poly-equivalent radical they contain. Each of the determinants† in the above examples, however, has two equivalencies; antimony acts as a triad and a pentad, carbon as a dyad and a tetrad. Dr. Frankland considers that in the highest compound of any radical its power of combination is saturated; this he calls the point

* H=1, O=16, C=12, Sn=118, Pt=197·4, Me=(CH_3), Et=(C_2H_5), Ho=(HO), etc.

† Dr. Wolcott Gibbs proposes the term "determinant" for the highest poly-equivalent radical in a compound, "object" for the body saturating it, and "resultant" for the product. In ammonia, for example, N is the determinant, H the object, and NH_3 the resultant.

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of atomic saturation. In this stage bodies can neither combine with other bodies nor replace them; and they cannot take part in any chemical change without undergoing decomposition. Below this point, however, there are in most cases certain points of comparative stability, at one of which this stability may be at its maximum, the compound undergoing decomposition less readily than when atomically saturated. Thus nitrogen atomically saturated is a pentad; but it has a trivalent and a univalent stage, of which the former is the stage of maximum stability. In this stage bodies may unite directly with or replace other bodies, thus acting like compound radicals. This fact Dr. Frankland explains by supposing that the units of attraction or *bonds* of an atom may saturate each other by pairs. Nitrogen as a pentad is $=\overset{|}{N}=$, as a triad $=\overset{|}{N}>$, and a monad $<\overset{|}{N}>$. The maximum number of bonds he calls the "absolute atomicity," the number of bonds united to each other "latent atomicity;" and those free to unite "active atomicity." The absolute atomicity equals of course the sum of the other two. The hexad iron forms ferrous chlorid $^{iv}Fe''Cl_2$, in which the active atomicity is two; ferric chlorid $'''Fe_2'''Cl_6$, in which it is three; and ferric acid $Fe^{vi}O_2Ho_2$, in which all the atomicity is active.

The book above mentioned is a synopsis of a course of lectures delivered at the Royal College of Chemistry in the fall of 1865–6, and is devoted to a development of these views. In all the rational formulæ it contains, the determinant is written first, printed in heavy type, thus: $\mathbf{O}H_2$, $\mathbf{Sn}O_2$, $\mathbf{Pt}Cl_4$, $\mathbf{O}OKo_2$; indicating that "it is united with all the active bonds of the other radicals, following upon the same line." With one atom of the determinant as above, formulæ are mon-adelphic; with two of equal power di-adelphic, etc. In the latter case one symbol is written below the other, connected by a bracket, thus: $\left\{\begin{matrix}\mathbf{O}H_3\\ \mathbf{O}H_3\end{matrix}\right.$. Dr. Frankland uses the bracket solely to signify that the atoms it connects exchange one bond. These atoms may be united indirectly as in methylic ether, $\left\{\begin{matrix}\mathbf{O}H_3\\ O\\ \mathbf{O}H_3\end{matrix}\right.$, where the dyad oxygen atom links them together. Speaking of rational formulæ the author says, "the formula ought to show, first, whether the hydrogen is combined with the carbon or with the oxygen; or if combined with both, it should indicate how many atoms are united with the carbon and how many with the oxygen. Secondly, the formula ought to show whether the oxygen be united with the carbon or with the hydrogen, or partly with the one and partly with the other; or, lastly, whether it be performing the function of linking hydrogen to carbon." p. 201. The representation in a formula of the mode in which the atoms are held together (and not of course their relative position in space) so necessary to explain cases of isomerism, and which cannot be given by the ordinary typical formulæ, is well obtained by those of Dr. Frankland. In aluminic oxyd, for example, $\left\{\begin{matrix}\mathbf{Al}O\\ \mathbf{Al}O\end{matrix}\right.O$, each aluminum atom exchanges one bond with its fellow, two with the dyad

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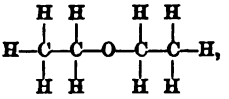
oxygen atom on the same line, and one with the single oxygen atom intermediate; in ethylic ether, $\left\{\begin{array}{l}\mathrm{CMeH_2}\\ \mathrm{O}\\ \mathrm{CMeH_2}\end{array}\right.$, the carbon atoms are linked by the oxygen atom, while the other three bonds of each are united respectively with one atom of Me and two of H. To farther elucidate this important fact of combination, Dr. F. makes use of the graphic notation of Crum Brown (using in lectures the glyptic formulæ of Hofmann).*

Aluminic oxyd is $\mathrm{O{=}\overset{\diagup\mathrm{O}\diagdown}{Al{-}Al}{=}O}$; and ethylic ether is

$$\begin{array}{ccccccccc} & & \mathrm{H} & \mathrm{H} & & & \mathrm{H} & \mathrm{H} & \\ & & | & | & & & | & | & \\ \mathrm{H} & - & \mathrm{C} & - & \mathrm{C} & - \mathrm{O} - & \mathrm{C} & - & \mathrm{C} - \mathrm{H}, \\ & & | & | & & & | & | & \\ & & \mathrm{H} & \mathrm{H} & & & \mathrm{H} & \mathrm{H} & \end{array}$$



in which the mode of union of the atoms is the same as that above given. These graphic methods, used more or less by Kekulé, Wurtz, Roscoe, Foster, etc., are most happy in the clearness with which they express the manner in which the bonds of an atom are saturated. Thus Dr. F. represents a molecule of oxygen as O=O, and one of ozone as $\mathrm{\overset{\diagup\mathrm{O}\diagdown}{O{-}O}}$. The formulæ of complex minerals given opposite pages 103 and 177, cannot fail to be of the highest value in mineralogy, if only we know enough of their constitution to say that these are their true rational formulæ.

Dr. Frankland has been remarkably successful in developing these views, and in applying them alike to mineral and organic chemistry. We notice, however, the objectionable term "anhydride" retained; while to our view the term "carbonic dioxide" of Foster (or "carbonylic oxide" $\mathrm{CO}\succ\mathrm{O}$) is far preferable. Again, we think his reason for excluding carbonic acid from the organic acids hardly sufficient. The volume deserves careful study. The novelty of many of its views, coming from so distinguished a chemist, are most suggestive, and cannot fail to exert an important influence upon theoretical chemistry. All the more important elements and compounds, with their modes of preparation, the reaction in each case, their physical and chemical properties, and their modes of decomposition, are most clearly described. And thus the object of the work, to furnish names, formulæ and reactions, and so to save to the student the time spent in copying these in the lecture room is most successfully accomplished.† G. F. B.

7. *Chemical Tables;* by STEPHEN P. SHARPLES, S.B. Cambridge, Sever & Francis, 1866. pp. 192.—We cannot give a better idea of the value of this book than by stating the heads under which the tables are arranged. Tables for the calculation of analyses; relating to specific gravity; relating to heat; for gas analysis; relating to light; miscellaneous tables. A table of logarithms closes the volume. A collection of physico-chemical constants like this cannot fail to be of great use both to the physicist and chemist. We need no higher endorsement of the work than that of Dr. Wolcott Gibbs, under whose supervision it was prepared.

* Not. Roy. Inst. of Great Britain, April 7, 1865.

† Quart. Jour. Chem. Soc., xiii, 177, and [2], iv, 372.

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8. *A new Chemical Nomenclature;* by S. D. TILLMAN, A.M., Professor of Technology in the Am. Inst. of the city of New York. pp. 23.—This paper was read before the American Association at the Buffalo meeting last August. Prof. T. attempts to embrace both nomenclature and notation in one mnemonical method, which is certainly very ingenious, and surprisingly successful. He exhibits an accurate acquaintance with chemical facts and relations. But his system does away with the old landmarks too entirely to be received into the philosophy of chemistry.

9. *Memoirs of the National Academy*, Vol I. pp. 344, 4to. Washington, 1866.—This first volume of the Memoirs of the National Academy of Sciences contains the following papers read before the Academy in 1864, 1865:

(1.) Reduction of the observations of the fixed stars made by Joseph Le Paute d'Agelet, at Paris, during the years 1783–1785, with a catalogue of the corresponding mean places referred to the equinox of 1800·0; by B. A. GOULD. (2.) On the Saturnian system; by BENJAMIN PEIRCE. (3.) On shooting stars; by H. A. NEWTON. (4.) On the distribution of certain important diseases in the United States; by AUGUSTUS A. GOULD. (5.) On rifled guns; by W. H. C. BARTLETT.

Dr. Gould's paper was noticed in this Journal in our last volume, and the principal part of Prof. Newton's appeared in vol. xxxix.

First Annual Report of the Geology of Kansas; by Prof. B. MUDGE, A.M. 56 pp., 8vo. Lawrence (Kansas), 1866. Report for the year 1864.

Preliminary Report of the Geological Survey of Kansas; by Prof. G. C. SWALLOW, State Geologist. 198 pp., 8vo. Lawrence, 1866. Report for the year 1866.

PROCEEDINGS BOST. NAT. HIST. SOC., Vol. X.—P. 358, Formation of the excavated lake basins of New England; *N. S. Shaler.*—Vol. XI. P. 1, Anatomy and physiology of the ciliary muscle in man; *B. J. Jeffries.*—p. 3, On a cat with supernumerary digits; *B. G. Wilder.*—p. 8, Formation of mountain chains; *N. S. Shaler.*

PROCEEDINGS ACAD. NAT. SCI. PHILADELPHIA, No. 3, June, July and August, 1866.—p. 236, Introduction of American shad into the Alabama river; *W. C. Daniell.*—p. 238, Description of some new species of Diurnal Lepidoptera; *Tryon Reakirt.*—p. 251, Contributions to the paleontology of Illinois and other western states; *F. B. Meek & A. H. Worthen.*—p. 275, Remarks on the remains of a gigantic Dinosaur from Cretaceous green sand of New Jersey; *E. D. Cope.*—p. 279, Notes on the Vespertilionidæ of tropical America; *H. Allan.*

PROCEEDINGS AMER. PHILOSOPH. SOC. PHILADELPHIA, Vol. X, No. 75.—P. 196, Observations on skylight polarization; *P. E. Chase.*—p. 199, Practical application of diamagnetism; *J. C. Cresson.*—p. 201, Native Siamese photography; *Dubois.*—p. 203, Odjibowé François dictionary; *G. A. Belconot.*—p. 206, The auroral display Feb. 20-21; *J. C. Cresson.*—p. 210, On Sullivant & Lesquereux's Musci Bor. Amer.; *T. P. James.*—p. 211, Obituary of Oswald Thompson; *E. K. Price.*—p. 223, On the comparative visibility of Arago's, Babinet's and Brewster's neutral points; *P. E. Chase.*—p. 227, Records of oil-borings (with map); *J. P. Lesley.*—p. 243, On some specimens of Indian pottery (with plate); *F. Peale.*—p. 246, Observations on some species of Spirifera; *J. Hall.*

PROCEEDINGS AMER. ACAD. ARTS AND SCI., Vol. VII.—P. 2, On certain formulæ of interpolation; *Ferrell.*—p. 31, An annual variation in the daily mean level of the ocean and its causes; *Ferrell.*—p. 37, Right ascensions observed at Harvard Coll. Observatory in the years 1862–1865; *T. H. Safford.*—p. 39, Some focal properties of quadratics; *J. E. Oliver.*—p. 52, On the Nephila plumipes, or silk-spider; *B. G. Wilder.*—p. 57, The aqueous lines of the solar spectrum; *J. P. Cooke, Jr.*—p. 68, Notes on the cells of the Bee; *J. Wyman.*—p. 84, New process of organic elementary analysis for substances containing chlorine; *C. M. Warren.*

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THE

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JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XVI.—*On the Decrease of the Rate of Increase of Population now obtaining in Europe and America;* by HORATIO ROBINSON STORER, of Boston, Professor of Obstetrics and the Diseases of Women in Berkshire Medical College.

(Read before the American Academy of Arts and Sciences, Dec. 14, 1858.)*

IN calling the attention of the Academy to some remarkable and hitherto unexplained facts in the present history of powerful nations, bearing upon their prosperity, progress and even their future existence, I beg heed to the various steps by which I shall arrive at certain astounding conclusions, of the deepest interest to political economists, as well as to moralists.

In many countries of Europe, it has been ascertained that the "fecundity" of the population, in other words the rate of its annual increase, is rapidly diminishing.

* The above paper, as will be seen, was prepared and read nearly ten years ago. It was thought best at the time to confine its discussion to the Medical profession, that any error either in statistics or reasoning might be detected. Portions of it were accordingly published in Philadelphia under the auspices of the American Medical Association, as correlative to the report of a committee, of which the writer was chairman. The event has shown the justice of his conclusions. Not an attempt even has been made to controvert them, while evidence in their favor has been steadily accumulating of an overwhelming character. Physicians are now of one mind as to the existence of the main facts proved. This has been shown by the authoritative issue for general circulation of the late Prize Essay of the Am. Med. Association (Why Not? A Book for Every Woman), and by the publication of corroborative testimony by many practitioners, in different parts of the country. This fact and the increased interest taken in the subject by the leading political economists of Europe, would show that the time was now ripe for its discussion by the scientific world.—H. R. S.

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In Sweden, it has lessened by one-ninth in sixty-one years; in Prussia, by a third in 132 years; in Denmark by a quarter in 82 years; in England, by two-sevenths in a century; in Russia, by an eighth in 28 years; in Spain, by a sixth in 30 years; in Germany, by a thirteenth in 17 years; and in France, by a third in 71 years.* Or, to reduce these fractions to decimals—in Sweden the rate of increase has lessened by a fifth, in Prussia by a fourth, in Denmark and England by a third, and in Russia, Spain, Germany and France by a half, in a single century.

For convenience sake, larger bodies of statistics existing concerning it, and from the fact that it represents the extreme of the alleged decrease, I shall take France as the basis of my comparisons.

In France at large, according to the official returns as analyzed by Legoyt,† the increase of the population, which from 1801–06 was at the rate of 1·3 per cent, annually, from 1806–46 had fallen to about ·5 per cent. The exact ratio of decrease after this period is better shown by the figures themselves. The increase from

1841–46	was	1,200,000
1846–51	"	380,000
1851–56	"	256,000

In England during the latter period, with a population of but one half the size, the returns of the Registrar-General showing a relative increase nine times greater.‡

In 37 years from 1817–54 the mean annual increase in France was not more than 156,000; yet in five years, from 1846–51, it had fallen to 76,000 yearly, and from 1851–56 to 51,200; and this, with a population ranging from 29 to 34 millions!

A comparison of these facts with those obtaining in other European states, will make the above still more evident.

TABLE I.—*Rate of increase in Europe* (according to Rau).§

		Per cent.			Per cent.
Hungary (Rohrer),		2·40	Netherlands,	1821–28	1·28
England,	1811–21	1·78	Saxony,	1815–30	1·15
"	1821–31	1·60	Baden (Hennisch),	1820–30	1·13
Prussia,	1816–27	1·54	Bavaria,	1814–28	1·08
"	1820–30	1·37	Naples,	1814–24	0·83
"	1821–31	1·27	France (Mathieu),	1817–27	0·62
Austria (Rohrer),		1·30	" more recently (DeJonnés),		0·55
Scotland,	1821–31	1·30			

A similar and corroborative table, containing additional matter, is given by Quetelet;‖ its differences from the preceding are owing to its representing a different series of years.

* Moreau de Jonnés, Eléments de Statistique, 1856, p. 202.
† Journal des Economistes, March and May, 1847.
‡ Edinb. Rev., Jan. 1857, p. 342; Med. Times and Gazette, May, 1857, p. 462.
§ Lehrbuch der Politischen Oekonomie.
‖ Sur l'Homme et le Développement de ses Facultés, tom. i, ch. 7.

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TABLE II.—*Rate of increase in Europe* (according to Quetelet).

	Per cent.		Per cent.
Ireland,	2·45	Austria,	1·30
Hungary,	2·40	Bavaria,	1·08
Spain,	1·66	Netherlands,	0·94
England,	1·65	Naples,	0·83
Rhenish Prussia,	1·33	France,	0·63

And more recently, Legoyt* brings up these results to the close of 1846, by census, and by the annual excess of births over deaths, and is therefore more reliable.

TABLE III.—*Rate of increase in Europe* (according to Legoyt) *by census.*

	Per cent.		Per cent.
England and Scotland,	1·95	Holland,	0·90
Prussia,	1·84	Austria,	0·85
Saxony,	1·45	Sweden,	0·83
Norway,	1·36	France,	0·63
Sardinia,	1·08		

TABLE IV.—*Rate of increase in Europe* (according to Legoyt) *by annual excess of births.*

	Per cent.		Per cent.
Norway,	1·30	Saxony,	0·90
Prussia,	1·18	Hanover,	0·85
Sweden,	1·14	Belgium,	0·76
Holland,	1·03	Bavaria,	0·71
Wurtemberg,	1·00	Russia,	0·61
England and Scotland,	1·00	France,	0·50
Denmark,	0·95	Normandy,	—
Austria,	0·90		

In four departments of France, among which are two of the most thriving of Normandy, the deaths actually exceed the births.†

From the above facts the general mortality not being excessive, it is evident that the percentage of births to the whole population must be smaller in France than in most other European countries; and from the lessened annual rate of increase of the population, that the percentage of births must be decreasing in similar ratio.

From larger statistics furnished by De Jonnés, I have compiled the following table of the comparative ratios of births to the population in the different countries of Europe.

TABLE V.—*Annual ratio of Births in Europe.*

Venice and dependencies 1827,	1 to 23	Sardinia 1820,	1 to 26
Tuscany 1834,	"	Naples and dependencies 1830,	"
Lombardy 1828,	1 to 24	Greece 1828,	"
Russia 1835,	1 to 25	Poland 1830,	1 to 27
Wurtemberg 1821–27,	"	Ireland 1821–31,	"
Prussia 1836,	"	Germany 1828,	"
Mecklenberg 1826,	1 to 26	Switzerland 1828,	"

* Journal des Economistes, May, 1847.
† Mill, Prin. of Pol. Econ., i, p. 343.

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TABLE V—continued.

Spain 1826,	1 to 27	Roman States 1836,	1 to 30
Portugal 1815–19,	1 to 27·5	Turkey 1835,	"
Sweden 1825,	1 to 28	Hanover 1835,	1 to 31
Austria 1829,	"	Sicily 1832,	"
Belgium 1836,	"	Austria 1828–30,	1 to 32
Bavaria 1825,	"	Great Britain 1821–31,	"
Two Sicilies 1831,	"	Scotland 1821–31,	1 to 34
Holland 1832,	"	England 1821–31,	1 to 35
Sweden and Norway 1828,	1 to 30	Norway 1832,	"
Denmark 1833,	"	France (1771, 1 to 25) 1851,	1 to 37

In a total population at different periods of 232,673,000, there were 8,733,000 births; whence an average on the grand scale of 1 birth to every 26·6 individuals.

In France, however, the ratio has been steadily lessening; as seen by the following table.

TABLE VI.—*Annual ratio of Births in France.*

1771–75,	1 to 25	1836–40,	1 to 34
1801–10,	1 to 30	1841–45,	1 to 35
1811–25,	1 to 32	1846–50,	1 to 37
1826–36,	1 to 33		

The position of France as compared with the rest of Europe, in respect to the ratio of births to the population at different periods can be made still more manifest.

TABLE VII.—*Comparative ratios of Births in Europe.*

1 to 23,	Venetian Provinces 1827, Tuscany 1834.
1 to 23·5,	Kingdom of Naples 1822–24.
1 to 24,	Tuscany 1818, Sicily 1824. Lombardy 1827–28, Russia 1831.
1 to 24·5,	Prussia 1825–26.
1 to 25,	*France* 1781, Austria 1827, Russia 1835, Prussia 1836.
1 to 26,	Sardinia 1820, Hanover, Wurtemberg and Mecklenberg 1826, Greece 1828, Naples 1830.
1 to 27,	Spain 1826, Germany, Switzerland 1828, Poland 1830, Ireland 1831.
1 to 27·5,	Portugal 1815–19.
1 to 28,	Holland 1813–24, Bavaria, Sweden 1825, Austria 1829, Belgium 1836.
1 to 29,	Canton Lucerne 1810, Holland 1832.
1 to 29·8,	*France* 1801.
1 to 30,	Sweden and Norway 1828, Belgium 1832, Denmark 1833, Turkey 1835, States of the Church 1836.
1 to 31,	Sicily 1832, Hanover 1835.
1 to 31·4,	*France* 1811.
1 to 31·6,	*France* 1821.
1 to 32,	Austria 1830, Great Britain, Switzerland 1831.
1 to 33,	*France* 1828–31.
1 to 34,	Norway, Holstein 1826, Scotland 1831, *France* 1834–41.
1 to 35,	Denmark 1810, England 1831, Norway 1832.
1 to 35+,	*France* 1851.

In Paris, strange to say, the decrease in the ratio of births to the population, though decided and steady, has not in actual proportion been as great as in the Empire at large; showing that the cause, whatever it may be, is not one depending on the influence of a metropolis alone for its existence.

From 1817–31 there averaged in Paris 1 birth to 26·87 inhabitants, and from 1846–51, 1 to 31·98.*

* Husson, Les Consummations de Paris, 1856.

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The facts thus far stated are admitted by the leading statisticians and political economists of the day, ignorant as they seem of much of the evidence soon to be brought forward, and of the conclusion to which the whole matter directly and with almost mathematical exactness may be proved to tend.

"In France," remarks De Jonnés, "the fecundity of the people is restrained within the strictest limits."*

"The rate of increase of the French population," says Mill, "is the slowest in Europe. The number of births not increasing at all, while the proportion of births to the population is considerably diminishing."†

We turn now to this country, to the commonwealth of Massachusetts.

In the state of Massachusetts, it has been found of late years that the increase of the population, or the excess of the births over the deaths, has been *wholly* of those of *recent foreign origin*.‡ This in 1850, and asserted of the state at large. In 1853, "it is evident that the births within the commonwealth, with the usual increase, have resulted in favor of foreign parents in an increased ratio."§ In other words, it is found that in so far as depends upon the American and native element and in the absence of the existing immigration from abroad, the population of Massachusetts is stationary or decreasing. This is shown also to threaten, even if we allow the foreign element to enter the calculation.

In 1850, the population of Massachusetts was by census 994,665, and the births were 27,664: in 1855 they were 32,845 and the population 1,132,369. The proportion of births to the population was therefore 1 to 36 in 1850, and in 1855 1 to 34; a ratio much smaller than that obtaining in most countries of Europe, and but little over that of France, which in 1850 was 1 to 37.‖

"This result," remarks Dr. Chickering, page 49 of the pamphlet just quoted, "will doubtless surprise many, who will hardly think it possible. Is it general or is it accidental? If it be general, how has it happened? What causes have been in operation to produce it? How is it to be accounted for?" These questions have hitherto been unanswered.

Decrease in the births of a nation, its lessened rate of increase,

* Eléments de Statistique, p. 195.

† Principles of Polit. Economy, i, pp. 343, 344.

‡ Chickering: Comparative View of the Population of Boston. 1850. City Document, No. 60, p. 44.

§ 12th Registration Report to the Legislature of Massachusetts, 1853, p. 116.

‖ The present statistics and others subsequently presented, I have computed from the fourteen published Registration Reports of the State of Massachusetts. Those concerning New York I have drawn from a series of official reports, kindly furnished me by the present City Inspector, Mr. Geo. W. Morton.

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must depend, according to one writer, De Jonnés, "either on physical agents, especially climate, or on the degree of civilization of a people, their domestic and social habits." "In France," he again remarks, "the climate is favorable to an increase of population, and this obstacle, this restraint, is found in its advanced civilization."*

"This diminution of births," says Legoyt, "in the presence of a constant increase of the general population and of marriages, can be attributed to nothing else than wise and increased foresight on the part of the parent."†

"The French peasant," writes Mill, "is no simple countryman, no downright '*paysan du Danube*;' both in fact and in fiction he is now '*le rusé paysan.*' That is the stage which he has reached in the progressive development which *the constitution of things has imposed on human intelligence and human emancipation.*"‡

"These facts," he again asserts, "are only to be accounted for in two ways. Either the whole number of births which nature admits of and which happen in some circumstances, do not take place; or if they do, a large proportion of those who are born, die. The retardation of increase results either from mortality or prudence; from Mr. Malthus's 'positive,' or from his 'preventive' check; and one or the other of these must and does exist and very powerfully too, in all old societies. Wherever population is not kept down by the prudence of individuals or of the state, it is kept down by starvation or by disease."§

But on the other hand, it has been forgotten by these writers that the alternative supposed does not exist in the case we have instanced. Marriages in France, unlike some other continental states, are continually increasing, and starvation and disease are yearly being shorn of their power.

If we turn to Massachusetts, these arguments acquire additional force. Amid such general thrift, abundance, wealth, in a state comparatively young and not over settled, there has been every reason for the population, general and native, as well as foreign, to increase. Want and excessive mortality are alike absent. Emigration westward and abroad, the only apparent positive check, extensive though this is, can by no means account for the evident facts. Conscription, war, despotism, restraining to a certain extent the population of France, are all unknown to ourselves. With the authors quoted, we are therefore forced to a single position, that this annual lessening of births must be owing, in great measure abroad, almost wholly with us at home, to '*prudence*' on the part of the community, not as a State, which ever encourages population, but as *individuals*.

Before proceeding, I would remark that the condition of things

* Loc. cit., pp. 194, 195.
† Journal des Economistes, 1847.
‡ Loc. cit., i, 336.
§ Ibid., i, 417.

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thus far described is such as political economists, almost without exception, approve, and that in great measure it is owing to the direct influence of their doctrines.

In his well known Essay on Population, Mr. Malthus remarks, that "in the average state of a well peopled territory, there cannot well be a worse sign than a large proportion of births, nor a better sign than a small proportion."*

A host of other authorities might be quoted, but a few extracts from a later writer, standard in this country at present and taught in our universities, till very lately in that of Cambridge for instance, will suffice.

"We greatly deprecate," says Mill, "an increase of population as rapid as the increase of production and accumulation."†

"There is room in the world no doubt, and even in old countries, for an immense increase of population. But although it may be innocuous, I confess I see very little reason for desiring it."‡

"I sincerely hope, for the sake of posterity, that they will be content to be stationary long before necessity compels them to it."§

"If the opinion were once generally established among the laboring class, that their welfare required a due regulation of the numbers of their families, only those would exempt themselves from it, who were in the habit of making light of social obligations generally."‖

"The principle contended for includes not only the laboring classes, but all persons, except the few who, being able to give their offspring the means of independent support during the whole of life, do not leave them to swell the competition for employment."¶

"When persons are once married, the idea never seems to enter any one's mind, that having or not having a family, or the number of which it shall consist, is at all amenable to their own control. One would imagine that it was really, as the common phrases have it, God's will and not their own, which decided the number of their offspring."**

"In a place where there is no room left for new establishments," says Sismondi, entirely ignoring the escapes offered by emigration and the increased importation of food, "if a man has eight children, he should believe that unless *six* of them die in infancy, these and three of his own contemporaries, of each sex, will be compelled to abstain from marriage, in consequence of his own imprudence."††

Having now explained an important cause of the effects I have described, I return from the digression.

* Loc. cit., p. 313. † Loc. cit., ii, 253. ‡ Ibid., ii, 316.
§ Ibid., ii, 317. ‖ Ibid., i, 451. ¶ Ibid., i, 452, footnote.
** Ibid., i, 447. †† Nouveaux Principes d'Economie Politique, liv, vii, ch. 5.

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Prudence, it is asserted, on the part of individuals checks and keeps within bounds the natural increase of the human race. We cannot well avoid allowing that this statement is true, and that it applies with even more pertinency to ourselves as a people than to nations abroad.

It will be profitable for us to go a step further, and to enquire in what way this result is effected; and though I shall be compelled to refer to matters usually thought best to keep concealed, and to present a conclusion at once frightful, astounding, degrading, I shall not shrink from the duty. For the subject is one which concerns each one of us, as philosophers, parents, as citizens, as christians.

There is no reason to suppose, as West,* Husson and DeJonnés have thought, that the rapid and constant decrease of births I have shown to exist can be attributable to any progressive lack of fecundity on the part of women, or of generative power on that of men; nor is there reason to think that the passions of the race burn less freely than formerly, or that they are more generally under control.

In a certain measure, no greater than formerly however, these needs are met by prostitution. Yet marriages and lawful connections have increased and now undoubtedly exist to a greater proportionate extent than ever before. They are confessed and easily proved, to be usually, either in whole or in great part, barren of offspring—we have only to look about us, for abundant evidence of this—while formerly, as is equally known, such was not the case.

Let all allowances be made for certain conjugal habits, existing extensively among the French, and by no means rarely imitated in this country, as unnatural and degrading as they are detrimental to the physical health of both male and female; but there exist a series of statistics, hitherto unknown, unappreciated or sedulously concealed, which prevent the increasing decrease of births from being thus, and only thus explained.

Prevention of pregnancy, to whatever extent existing, cannot account for the decrease of living births; actual pregnancies being proved fully as frequent as ever. What then can? We answer the question by another.

"Has it been sought," asks Quetelet, in his Theory of Probabilities, though he did not attempt to solve the problem, so puzzling to statistician, philanthropist and statesman, "to account for the peculiarities relating to the still-born, and to combat the causes which in certain circumstances swell their number in so deplorable a manner?"†

I shall show that nearly as many pregnancies exist as ever. We are to consider these pregnancies, not as prevented, but as terminated without the birth of a living child.

* Med. Times and Gazette, June, 1856, p. 611. † Loc. cit., p. 234.

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I am aware that the evidence of statistics is received by many minds with a certain measure of doubt; but I shall endeavor so to add proof to proof, and to draw these from such authoritative sources, that no doubt can fairly remain. I base my remarks upon the following self-evident laws.

1st. That, while a result or event in *individual* instances is ever variable and uncertain, this result or event when calculated from or upon *masses* of instances becomes proportionately certain and invariable.

2d. That, to apply this principle to the case we are now considering, the *absolute* number of *living births* in a given population, in a given time, should, in the absence of an evident and sufficient disturbing cause, be always nearly the same; increasing with the increase of the population, and with the progress of medical science (which might easily be proved to be in this respect constantly advancing).

3. That the *absolute* number of *still births at the full period of pregnancy*, occurring from natural causes in a given time in a given population should be always nearly the same; increasing only in proportion to the actual increase of the population, and decreasing with the progress of medical science.

4th. That the *absolute* number of *premature* births, occurring from natural causes in a given time in a given population should be always nearly the same; increasing only in proportion to the actual increase of the population, and decreasing with the progress of medical science.

5th. That the *relative* number of *still births from natural causes*, at the full period of pregnancy and premature, as compared with the *living* births in a given population in a given time should be always nearly the same; *not* being affected by an increase of population, and constantly lessened by the progress of medical science.

6th. That the *relative* number of *still births from natural causes*, at the full period of pregnancy and premature, as compared with the *general mortality* in a given population in a given time, should remain always nearly the same, not being affected by an increase of population and but slightly by the progress of medical science.

7th. That the *relative* number of *still births from natural causes*, premature and at the full period of pregnancy, should remain always nearly the same compared with each other; neither of them being affected by the increase of population and each of them nearly equally by the progress of medical science.

It has already become manifest that the 2d of these propositions does not accord with existing facts; that the *absolute* number of *living* births in Europe and in this country does not remain the same, time and population agreeing; that instead of

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increasing with the increase of the latter and with the progress of medical science, it has been rapidly and steadily diminishing.

In the discord of existing facts with the remaining propositions also, I have detected and shall make evident the disturbing cause.

Since 1805, when returns were first made to the Registry of New York, the number, proportionate as well as actual, of fœtal deaths in that city has steadily and rapidly increased. With a population at that time of 76,770, the number of still and premature births was 47; in 1849, with a population estimated at 450,000 the number had swelled to 1320.* Thus while the population had increased only *six* times since 1805, the annual number of still and premature births had multiplied over *twenty-seven* times! The following table shows the rapidity of this increase.

TABLE VIII.—*Ratio of Fœtal Deaths to the population in New York.*

1805,	1 to 1633·40	1830,	1 to 597·60
1810,	1 " 1025·24	1835,	1 " 569·88
1815,	1 " 986·46	1840,	1 " 516·02
1820,	1 " 654·52	1845,	1 " 384·68
1825,	1 " 680·68	1849,	1 " 340·90

In the three years preceding 1849, there were registered in New York 400 premature births and 3,139 children still born; a total of 3,539, representing at that time a yearly average of some 1200 fœtal deaths. It is evident that though almost all the still births at the full time, even from criminal causes, are necessarily registered, but a small proportion of the abortions and miscarriages occurring are ever reported.

In the three years preceding 1857, there were registered in New York 1196 premature and 4735 still births, a total of 5931, representing a yearly average of some 2000 fœtal deaths; showing that in the short space of seven years, the number of fœtal deaths in New York, already enormous, had very nearly doubled!

I now present a table showing the ratio of still births to the living births in various countries of Europe.

TABLE IX.—*Ratio of Still to Living Births in Europe.*

Geneva 1824–33,	1 to 17	Prussia 1820–34,	1 to 29
Berlin (hospitals) 1758–74,	1 to 18	Iceland 1817–28,	1 to 30
Paris (Maternité) 1816–35,	1 to 20	Prague 1820,	1 to 30
Sweden 1821–25,	1 to 23·5	London (hospitals) 1749–81,	1 to 31
Denmark 1825–34,	1 to 24	Vienna 1823,	1 to 32
Belgium 1841–43,	1 to 24·2	Austria 1823,	1 to 49

In France at large in 1853 the ratio was 1 to 24. Department of Seine 1 to 15. In the city of Paris 1836–44, 1 to 14·3; in 1845–53, 1 to 13·8. The proportion of still births in the rural districts of France is governed by the same laws as in the metropolis. In 363 provincial towns the ratio was, in 1836–45, 1 to 19·5; in 1846–50, 1 to 18·8.

* Report of the City Inspector for 1849.

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While districts more thinly populated gave, in 1841–45, 1 to 29; 1846–50, 1 to 27.*

In Belgium, during a similar period, the ratio was much the same. It was, in 1841–43, in towns 1 to 16·1, in country 1 to 29·4.†

The apparent discrepancy between city and country, noticed as equally obtaining in Belgium and France, is probably owing in great measure to greater negligence of the country officials in registering the still births.

Again, the total number of births at the full time in New York in 1856 was 17,755; of these, 16,199 were living;‡ proving that of children at the full time alone, setting aside the great number of viable children born prematurely, and the innumerable earlier abortions not recorded, 1 in every 11·4 is born dead.

From foreign statistics on a large scale, embodied in the table we have already given, it is found that the proportion of still births does not in those countries drop below 1 in 15, and this in France; ranging from that number up to 1 in 30 or 40 of the whole number of births reported.

In Geneva, out of 10,925 births occurring from 1824–33, 1,221 of them *illegitimate* and therefore to be supposed liable to a large percentage of deaths from criminal causes, there were only 646 fœtal deaths; a proportion of 1 in 17.

In Belgium, there were 29,574 *illegitimate* births from 1841–43, and of these 1,766 were born still,§ or 1 in 16·8.

In New York, from 1854–57, there were 48,323 births; and 5,931 still births, at the full time and prematurely; or in other words, 1 to every 8·1 was born dead.

In Massachusetts, the ratio of still births, at the full time and premature, as compared with the living births in 1850, was 1 to 15·5. In France it is 1 to 24, and in Austria 1 to 49. While the proportion of still births at the full time to the whole number is enormous and steadily increasing, so is the number of known abortions and premature births.

The frequency of these occurrences reported from the practice of physicians, and thus to a certain extent but not entirely, likely to be of natural and accidental origin, is as follows: in 41,699 cases registered by Collins, Beatty, La Chapelle, Churchill and others, there were 530 abortions and miscarriages. Here all the abortions were known; their proportion was 1 to 78·5.

In New York, from 1854–57, there were 48,323 births reported as at the full time and 1,196 premature. Here all the abortions were not known, probably but a very small fraction of them; the proportion was 1 to 40·4.

* De Jonnés, loc. cit., p. 239.

† Quetelet, loc. cit., p. 152.

‡ City Inspector's Report for 1856.

§ Compiled from Quetelet, p. 152.

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In Massachusetts, the ratio of premature births to those at the full time, as recorded in the registration reports, during the period from 1850–56, was 1 to 26·1.

That the ratio of still births and abortions, already so frightful, is steadily increasing, is also seen by the following table; in which we have compared the still births, supposable perhaps of accidental value, with the general mortality, whose value is at least as accidental.

TABLE X.—*Ratio of the Fœtal to the general mortality in New York.**

	Total deaths.	Fœtal deaths.	Ratio.
1804–09	13,128	349	1 to 37·6
1809–15	14,011	533	1 to 26·3
1815–25	34,798	1,818	1 to 19·1
1825–35	59,347	3,744	1 to 15·8
1835–55	289,786	21,702	1 to 13·3
1856	21,658	1,943	1 to 11·1

In 1851, the ratio of fœtal deaths in Massachusetts to the general mortality was 1 to 13·3; in 1855, 1 to 10·4, larger than in New York city a year later. In a metropolis we should expect the proportion to be greater than in a state at large; it is here less.

Finally we compare the recorded premature still births of New York, with those still at the full time.

In the seventeen years from 1838–55, there were reported 17,237 still births at the full time, and 2,710 still prematurely; the last bearing the proportion of 1 to 6·3.

In the nine years from 1838–47, omitting 1842 for the reason that the reports to the Registrar for that year were confessedly imperfect, there were 632 still premature births, and 6,445 still at the full time; a yearly average of 1 to 10·2.

In the eight years from 1848–55, there were 2,078 premature still births, and 10,792 still at the full time; an average of 1 to 5; while in 1856, there were 387 still prematurely, and 1,556 at the full time; or 1 to 4·02!

On the other hand, there were recorded in Massachusetts during the 14 years and 8 months preceding 1855, 4,570 still births and 11,716 premature births and abortions,† the ratio being 1 abortion to ·3 still births; or in other words it would appear from the statistics quoted, that the comparative frequency of abortions in Massachusetts is 13 times as great as in the worst statistics of the city of New York!

We are willing however, we rejoice, to modify this statement, as in the earliest of the years quoted, returns from the city of Boston seem to have been imperfect or wanting. We therefore confine ourselves to a more recent period.

From 1850–55, the registration being much more accurate than before, and its results compiled with the greatest care, three

* Compiled from City Inspector's Reports for 1855–6.

† 14th Registration Report, 1855.

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years of the five by a noted statistician, Dr. Shurtleff, there were recorded in Massachusetts 2,976 still births and 5,899 premature births and abortions, the ratio being 1 abortion to ·5 still births; in other words, the frequency of abortions as compared with still births at the full time is at least 8 times as great in Massachusetts as in the worst statistics of the city of New York.*

It is allowed by political economists, by Mill and by Malthus himself, that so much of the existing decrease as cannot otherwise be explained, must be attributed to influences generally prevalent in Europe during earlier ages, and in Asia to the present time. "Throughout Europe," says Mill, "these causes have much diminished, but they have nowhere ceased to exist."† Several of these causes, starvation, wars, disease, have been named by the authority now quoted, but the greatest of them all is left unspoken.

The wilful destruction of living children, at and before birth, history declares to have obtained, and to a very great extent, among all the earlier nations of the world, the Jews alone excepted. Aristotle‡ defends it, and Plato.§ It is mentioned by Juvenal,‖ Ovid,¶ Seneca and Cicero; and it is denounced by the early Christians.** It was common in Europe through the middle ages, and still prevails among the Mahometans, Chinese, Japanese, Hindoos, and most of the nations of Africa and Polynesia to such an extent that it may well be doubted whether more have ever perished in those countries by plague, by famine and the sword.

It is impossible that the facts I have quoted from present history can in any great measure be owing to natural causes alone. They are wholly inexplicable on any principles which do not recognize an amount of guilt at which humanity shudders.

We have seen that with us, in the absence of all influences that tend to keep down population in foreign countries, old and crowded, and under the yoke of despotism, the effects attributable elsewhere to these causes, exist and to an *extreme* degree. That the ratio of fœtal deaths to the population had swelled in New York from 1 in 1633 in 1805 to 1 in 340 in 1849, while in France at a later period, 1851, they were only 1 in 1000. That the actual number of fœtal deaths in that city had in the 7 years from 1850–57, very nearly doubled. That the fœtal deaths as compared with the total of births, elsewhere in statistics of illegitimacy alone, where the results are supposed worst and confessed chiefly from crime, being 1 in 16·8 (Belgium), had here,

* The above remarks are not to be misunderstood. In Massachusetts registration has been conducted with greater care than elsewhere. Subsequent investigations have proved that both infanticide and fœticide prevail to an equal extent in many other of our states.

† Loc. cit., i, 417.

‡ Travels of Anacharsis, v, 270.

§ Ibid., iv, 342.

‖ Satires, vi, 592.

¶ Amor., lib. 2; Heroides, epist. 2.

** Reeve's Apologies.

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legitimate and natural, reached the frightful ratio of 1 in 8. That the fœtal deaths as compared with the total mortality, had increased from 1 in 37 in 1805, to 1 in 13 in 1855. That the reported early abortions, of which the greater number of course escape registry, bear the ratio to the living births of 1 in 40, while elsewhere they are only 1 in 78. And finally, that early abortions, bearing the proportion to the still births at the full time of 1 in 10 in 1846, had increased to 1 in 4 in 1856.

So far the city of New York—a metropolis, and claiming pre-eminence neither in morals nor religion. On the other hand in Puritan Massachusetts, in the State at large, and therefore but little affected by the statistics of its capital, which however would by themselves probably be found corroborative of the main result, we have seen that the ratio of still births at the full time and premature as compared with the living births in 1850, was 1 to 15·5. In France it is 1 to 24, and in Austria 1 to 49. That the ratio of premature births to those at the full time, during the period from 1850–56 was 1 to 26, while in New York city it is only 1 to 40. That the ratio of fœtal deaths to the general mortality was 1 to 13 in 1851, and in 1855 1 to 10·4; while in New York city a year later, in 1856, it was only 1 to 11; and that from 1850–55 the frequency of abortions as compared with still births at the full time, was at least eight times as great as in the worst statistics of the city of New York.

Few persons could have believed possible the existence of such frightful statistics, the result toward which they must be confessed inevitably to tend, or the dread cause from which they spring. Either these statistics must be thrown aside as utterly erroneous and worthless, or they must be accepted with their conclusions. We would gladly do the former, but they present too many constant quantities in other respects, as for instance, in the regularly progressive series of deaths and births as compared with the population, constant also as compared with each other, for this to be allowed. My own calculations have been made with care, and I have presented the elements on which they rest. In asserting the results, at once so awful and astounding, I desire to fix upon them the attention and scrutiny of the Academy.

These conclusions however do not rest alone on the statistics that have been presented. The experience of courts of justice, and that equally extensive tribunal, the body of physicians throughout our land, (I regret, and at the same time rejoice, Mr. President, that this assertion is not borne out by your own extended experience,)* tend to corroborate them, and other evidence of equal weight and character is at hand.

* Dr. Jacob Bigelow, then President of the Academy, was inclined at one time to disbelieve in the existence of certain customs everywhere prevalent among us. He subsequently publicly acknowledged however, that his doubts were owing to his not having personally investigated the subject.

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In seeking for the *causes* of these facts, I have found much that is interesting, and somewhat that I believe to have been hitherto unpresented.

The immense proportion of living births to the pregnancies in the foreign as compared with the native and protestant population of Massachusetts, already referred to, is to be explained by the watchful protection exercised by the Catholic church over fœtal life. However we may regard the dogma on which this rests, the sanctity of infant baptism, there can be no question that it has saved to the world millions of human lives. But of the various corroborative testimony to which I have alluded, and of other matters pertaining to this subject I shall elsewhere speak.*

Were mankind, in following the advice that has been quoted from past and present authorities in political economy, content merely to practice greater abstinence and greater prudence in sexual matters, less blame could justly be laid. But when we find infanticide and criminal abortion thus justified, rendered common and almost legitimated, we may well oppose to the doctrine of these cruel teachers the words of the indeed admirable Percival, "To extinguish the first spark of life is a crime of the same nature, both against our Maker and society, as to destroy an infant, a child, or a man."†

ART. XVII.—*Research on the Ethers of Silicic Acid;* by C. FRIEDEL and J. M. CRAFTS.

THE determination of the atomic weight of silicium has given rise to more discussion than that of any other element; nor does this astonish us, when we consider the number and complicated nature of the compounds of silicium and the peculiar properties which separate it from all the other elements.

Even at the present day chemists and mineralogists are not agreed whether to write silica SiO_2 or SiO_3, and recently Scheerer‡ has published a paper, in which he brings up the old arguments in favor of the latter formula, and adds to them some new ones, based on the study of the action of silicic acid on carbonate of soda at a red heat, as well as on Wöhler's research on leucon.§ We will not discuss these arguments, as we think that a sufficient reply to them will be found in the facts brought to light by this research, facts which are impossible to reconcile with the opinion of Prof. Scheerer.

* North American Medico-Chirurg. Review; Philadelphia, Jan. 1859, et seq.
† Med. Ethics, p. 79.
‡ Journ. für praktische Chemie, xci, 415.
§ Ann. der Chem. u. Pharm., cxxvii, 257.

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It is not our intention to enter into the history of the discussion of the true atomic weight of silicium; but it will perhaps be useful to recall some of its principal phases. In the memorable series of investigations by which Berzelius, without following any fixed rule, but with an accuracy of perception all the more remarkable, established the greater part of the atomic weights, he assigned to silicic acid the formula* SiO_3 (Si=21, O=8). He deduced this result from the analyses of various silicates, particularly of orthoclase, relying upon an analogy which he supposed to exist between silicic and sulphuric acids.

Dumas, when he called the attention of chemists in his classical memoir† to the importance of the determination of the density of vapors and its value in establishing chemical formulæ, gave, among other examples, that of the chlorid of silicium. According to him this body ought to have the formula $SiCl_2$, and consequently silicic acid SiO (Si=7, O=8, Cl=17·75). The chlorids of tin and titanium follow the same law.

Some years later Gaudin,‡ among other remarkable deductions from the law of Ampère, obtained the formulæ $SiCl_4$ and SiO_2 for the chlorid of silicium and for silicic acid. At the same time he noticed the analogy between silicic and carbonic acids. These ideas do not appear to have attracted the attention they merited, because they were too far in advance of those received at the time, and those who have since taken them up have doubtless been unintentionally unjust in not quoting their author.

Ebelmen employed the atomic weight for silicium as established by Dumas, and wrote the formula of silicic ether,

$$SiO, C_4H_5O, (Si=7, O=8, C=6, H=1).$$

This is the most simple expression for the result of his analysis, but his formula is not in accordance with that of Dumas for silicic acid; for in order to correspond with it, silicic ether should be written $SiO, C_4H_{10}O$, as if it contained two atoms of ethyl.§ Indeed Ebelmen's formula implies a hypothesis quite distinct from that, founded on the vapor-density of chlorid of silicium, for, to use the nomenclature of the present day, the first formula represents silicium as monoatomic, and the second as diatomic.

Gmelin‖ wrote the chlorid of silicium and silica $SiCl_2$ and SiO_2 (Si=14, Cl=35·5, O=8), and these formulæ were adopted by the greater number of chemists, and they found a new argu-

* Essai sur la Théorie des proportions Chimiques, p. 134; Paris, 1819.

† Ann. de Chim. et Phys., [2], xxxiii, 367; 1826.

‡ Ann. de Chim. et Phys., [2], lii, 113; 1833. We will add that in this memoir Mr. Gaudin gives the definition of atom and molecule which is received at the present day. And we are happy in being able to render justice to an acute intellect, whose penetration has not been sufficiently recognized.

§ Ann. de Chim. et Phys., [3], xvi, 141; 1846.

‖ Handbuch der Chemie, ii, 339; Heidelberg, 1844.

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ment in their favor in the brilliant researches of Marignac on the isomorphism of fluosilicates, fluotitanates, and fluostannates.*

When the progress of organic chemistry forced the chemists, after Gerhardt, to double the atomic weights of oxygen and carbon, leaving that of hydrogen =1, which was nothing else than returning to the old relations of Berzelius and Dumas, the question arose, whether silica ought to be written

$$SiO\ (Si=14,\ O=16)\ \text{or}\ SiO_2\ (Si=28).$$

Gerhardt answered the question implicitly in favor of the latter formula, when he wrote silicic ether† $4(SiO)$, $4(C_4H_5O)$, and without doubt his only motive for retaining the atomic weight of Ebelmen ($Si=7$) was the same, which prevented him from changing those of carbon and oxygen in his work on organic chemistry. In order to have been consistent with his own theoretic views, he need only have gone back to the formula of Gaudin. Odling‡ has done this, and writes silica SiO_2, and considers SiH_4O_4 as the normal hydrate of silicic acid, to which the ethers correspond.

Odling, as well as Gerhardt and Gaudin before him, have deduced these formulæ from the consideration of the vapor-density of the chlorid of silicium and of silicic ether. This must be regarded as an important argument in their favor, and to deny its value it would be necessary to forget the admirable order introduced by Gerhardt in the classification of organic compounds in the place of the confusion which reigned before the vapor-density was employed as a criterion to determine the molecular weight of compounds. It would be necessary, also, to ignore the important results obtained by various chemists, particularly by Wurtz§ and Cannizzaro,‖ in the fixation of molecular weights according to the same law.

Nevertheless we must remember that the ideas of Avogadro and Ampère are nothing more than a physical hypothesis; and although this hypothesis has been fruitful in accurate conclusions, even from the stand-point of a chemist, it must yield before purely chemical considerations in the determination of the relative weights of atoms and molecules. This conviction has led us to study the organic compounds of silicium in the hope of obtaining results which would enable us to resolve, on entirely chemical grounds, the question of the true atomic weight of silicium, and we must also admit, with the hope of confirming by our research the conclusions drawn from the law of Ampère.

* Ann. des Mines, [5], xv, 221. † Traité de Chimie Organique, ii, 363.
‡ Philosophical Magazine, xviii, 368.
§ Leçons de Philosophie Chimique; Paris, 1864.
‖ Sunto di un Corso di Filosofia Chimica; Pisa, 1858.

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We believe that we have succeeded in demonstrating that the most simple formulæ possible for silicic acid and the normal silicic ether are $Si\Theta_2$ and $Si, 4(C_2H_5\Theta)$, and in consequence, that the true atomic weight of silicium is 28.

*Silicate of ethyl.**—We chose as point of departure for our research the silicic ether, discovered and studied by Ebelmen. In regard to this body we have little to add to the facts recorded by him. The ether was prepared as recommended by him, taking care to use absolute alcohol, and to add it in small quantities at a time to the chlorid of silicium. When the alcohol is perfectly anhydrous, the quantity of ether obtained is almost equal to the theoretical; however, a small quantity of chlorid of silicium is always carried off by the hydrochloric acid gas which escapes.

Silicic ether, purified by repeated distillation, boils at 165°·5. We determined its density at 0° C. =0·9676. Ebelmen gives the density at 20° C. =0·933. The moisture of the air transforms it rapidly into a solid body, silicic acid; a piece of which, after being kept three years, became hard enough to scratch glass. Notwithstanding its decomposability by moisture, the ether remains unaltered for some time under water, and when it is distilled with water, only traces of silica remain behind in the vessel. These facts must be attributed to its nearly complete insolubility in water, for aqueous alcohol transforms it immediately into a polysilicate, as Ebelmen has already observed. All the water contained in the alcohol does not react immediately upon the ether, for when it is heated during a long time in a closed tube with aqueous alcohol, a larger quantity of polysilicate is obtained than when the two liquids are merely distilled together.

Assigning, like Gerhardt and Odling, the formula $Si, 4(C_2H_5\Theta)$ to silicic ether, we are naturally led to think that it would be possible to replace one-quarter of the ethyl and oxygen $(C_2H_5\Theta)$ by chlorine; as in the diethylic lactic ether an atom of peroxyd of ethyl $(C_2H_5\Theta)$ can be replaced by chlorine with formation of chlorolactate of ethyl.

Diethylic lactic ether.

$$\left.\begin{matrix} C_3H_4\Theta \\ 2(C_2H_5) \end{matrix}\right\}\Theta_2$$

Normal silicate of ethyl.

$$\left.\begin{matrix} Si \\ 4(C_2H_5) \end{matrix}\right\}\Theta_4$$

Chlorolactate of ethyl.

$$\left.\begin{matrix} C_3H_4\Theta \\ C_2H_5 \\ Cl \end{matrix}\right\}\Theta$$

Monochlorhydrine of silicic ether.

$$\left.\begin{matrix} Si \\ 3(C_2H_5) \\ Cl \end{matrix}\right\}\Theta_3$$

In case of silicic ether, we ought to be able to go further, and not only replace one but several atoms of peroxyd of ethyl by chlorine, and obtain the bodies

* The atomic weights used are $Si=28$, $\Theta=16$, $C=12$, $H=1$.

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Dichlorhydrine of silicic ether. Trichlorhydrine of silicic ether.

$$2\left(\begin{matrix}\text{Si}\\ \text{C}_2\text{H}_5\\ \text{Cl}_2\end{matrix}\right\}\text{O}_2 \quad \text{and} \quad \left.\begin{matrix}\text{Si}\\ \text{C}_2\text{H}_5\\ \text{Cl}_3\end{matrix}\right\}\text{O}$$

Monochlorhydrine of silicic ether.—This ether was obtained by heating in a sealed tube during one hour at 150° C. three molecules of normal silicic ether with one molecule of chlorid of silicium. The reaction is

$$\text{SiCl}_4+3\left(\left.\begin{matrix}\text{Si}\\ 4(\text{C}_2\text{H}_5)\end{matrix}\right\}\text{O}_4\right) = 4\left[\left.\begin{matrix}\text{Si}\\ 3(\text{C}_2\text{H}_5)\\ \text{Cl}\end{matrix}\right\}\text{O}_3\right].$$

On distilling the contents of the tube we noticed that there was no free chlorid of silicium remaining. The liquid commenced to boil at 145°, and almost the whole product passed between 153°–160°. After several fractionated distillations, we analyzed the product boiling at 155°·7–157°.

I.	Substance weighed,	0·3785 gr.
	CO_2,	0·5005 "
	H_2O,	0·2545 "
II.	Substance, weight,	1·4545 "
	AgCl,	1·0650 "
	SiO_2,	0·4355 "

We will also give here the result of an analysis of monochlorhydrine prepared by the action of chlorid of acetyl on silicic ether, and boiling 155°–157°.

III.	Substance, weight,	0·2190 gr.
	CO_2,	0·2935 "
	H_2O,	0·1525 "

		I.	II.	III.	Theory.
C	=	36·06		36·55	36·27
H	=	7·46		7·74	7·55
Si	=		13·95		14·10
Cl	=		18·11		17·88

The determination of silicium and chlorine was made by decomposing the body in a flask with an alcoholic solution of ammonia, distilling the alcohol and heating the flask in order to render the silica easy to wash upon a filter. The chlorine was determined in the filtrate from the silica. The alcohol carries over with it on distillation a little NH_4Cl, and it must be carefully condensed and evaporated slowly and the residue added to the filtrate from the silica.

The monochlorhydrine of silicic ether is a colorless liquid, which does not fume in the air, but is rapidly decomposed by moisture or by water with evolution of HCl. It reacts easily on alcohol; HCl is given off and normal silicic ether is formed. It burns with a green flame due to chlorine and with a smoke composed of silicic acid.

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Its density at 0° compared with that of water at the same temperature =1·0483. Its vapor density was found to be 7·05. The theory of a condensation to two vols. requires 6·87.

The data for the determination are:

Difference between two weights of bulb,	1·1975 gr.
Temperature of the balance, - -	12°
" " oil-bath, - -	230°
Height of barometer, - - - -	762·8 mm.
Capacity of bulb, - - - -	323 cc.
Air remaining in bulb, - - - -	2 cc.

We obtained the same chlorhydrine by heating for about one hour at 170°–180° one molecule of chlorid of acetyl with one molecule of silicic ether. The products of the reaction are acetic ether and the monochlorhydrine, and the reaction may be represented by the equation:

$$\left.\begin{matrix}\text{Si}\\ 4(\text{Є}_2\text{H}_5)\end{matrix}\right\}\Theta_4+\text{Є}_2\text{H}_3\Theta,\text{Cl}=\left.\begin{matrix}\text{Si}\\ 3(\text{Є}_2\text{H}_5)\\ \text{Cl}\end{matrix}\right\}\Theta_3+\left.\begin{matrix}\text{Є}_2\text{H}_3\Theta\\ \text{Є}_2\text{H}_5\end{matrix}\right\}\Theta.$$

40 grams of silicic ether, heated with 24 grams of chlorid of acetyl, gave 25 grams of acetic ether, nearly pure, and boiling at 75°–80°. The theory requires 27 grams. Almost the whole of the remainder of the product passed at 155°–158°.

The experiment was undertaken with the object of obtaining an aceto-silicate of ethyl, supposing that the reaction would take place according to the equation:

$$\left.\begin{matrix}\text{Si}\\ 4(\text{Є}_2\text{H}_5)\end{matrix}\right\}\Theta_4+\text{Є}_2\text{H}_3\Theta,\text{Cl}=\left.\begin{matrix}\text{Si}\\ 3(\text{Є}_2\text{H}_5)\\ \text{Є}_2\text{H}_3\Theta\end{matrix}\right\}\Theta_4+\text{Є}_2\text{H}_5\text{Cl},$$

but no trace of such a body was formed.

The monochlorhydrine of silicic ether is also formed when the ether is heated with the perchlorid of phosphorus; there is formation of a small quantity of oxychlorid of phosphorus and of other more volatile compounds containing phosphorus. A large quantity of chlorid of ethyl is given off. The product obtained in this reaction and boiling at 155°–158° was used to prepare the triethylic mono-amylic silicic ether. See below.

The dichlorhydrine of silicic ether is obtained by a reaction analogous to that which gives monochlorhydrine, by heating together one molecule of silicic ether and one molecule of chlorid of silicium.

$$\text{SiCl}_4+\left.\begin{matrix}\text{Si}\\ 4(\text{Є}_2\text{H}_5)\end{matrix}\right\}\Theta_4=2\left[\left.\begin{matrix}\text{Si}\\ 2(\text{Є}_2\text{H}_5)\\ \text{Cl}_2\end{matrix}\right\}\Theta_2\right].$$

It can also be prepared by heating monochlorhydrine with the chlorid of silicium.

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$$SiCl_4 + 2\left[3\left(\begin{matrix}Si\\(C_2H_5)\\Cl\end{matrix}\right\}O_3\right] = 3\left[2\left(\begin{matrix}Si\\(C_2H_5)\\Cl_2\end{matrix}\right\}O_2\right].$$

The reaction takes place somewhat less readily than the one which gives rise to the monochlorhydrine, and it is necessary to heat the sealed tubes longer and to separate the product by a larger number of fractionated distillations. While manipulating the chlorhydrines the utmost care must be taken to prevent exposure to the moisture of the atmosphere, which decomposes them the more readily the more chlorine they contain. The vases containing the different products were always kept in a glass jar, which had the bottom covered with sulphuric acid and a glass cover fitting air-tight.

The dichlorhydrine boils at 136°–138°. Analyses gave:

I.	Substance, weight, - - - -	0·3480 gr.
	CO_2, - - - - - -	0·3270 "
	H_2O, - - - - - -	0·1675 "
II.	Substance, weight, - - - -	0·7005 "
	AgCl, - - - - - -	1·0635 "
III.	Substance, weight, - - - -	0·3250 "
	SiO_2, - - - - - -	0·1000 "

	I.	II.	III.	Theory.
C,	25·62	....	....	25·39
H,	5·35	....	....	5·29
Cl,	....	37·54	....	37·56
Si,	....	....	14·35	14·81

The vapor-density is 6·76; theory 6·545. Data:

Difference of 2 wts. of bulb,	0·8695 gr.	
Temperature of balance, -	22°	
" " oil-bath, -	213°	Air thermometer 211°·5
Height of barometer, -	766·9 mm.	
Capacity of bulb, - -	229·6 cc.	
Air remaining in bulb, -	0·3 cc.	

The density at 0° of the dichlorhydrine is 1·144. This body resembles the monochlorhydrine in all its physical properties.

The trichlorhydrine of silicic ether is obtained by heating for several hours at 150°, either the silicic ether or the two preceding chlorhydrines, with an excess of chlorid of silicium, and separating the products by a large number of fractionated distillations. The precautions that were taken to keep the other chlorhydrines from contact with moisture are still more necessary in the case of the trichlorhydrine. It boils at 103°–105°. Analyses gave:

I.	Substance, weight, - - - -	0·3995 gr.
	CO_2, - - - - - -	0·1976 "
	H_2O, - - - - - -	0·1040 "

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II.	Substance, weight, - - - - -	0·5945 gr.
	AgCl, - - - - - - -	1·4190 "
III.	(Boil. point =104°–106°.) Substance, wt.,	0·4235 "
	$C\Theta_2$, - - - - - - -	0·2100 "
	$H_2\Theta$, - - - - - - -	0·1070 "
IV.	Substance remaining in the bulb after the determination of the vapor-density, weight, - - - - - -	0·5465 "
	$Si\Theta_2$, - - - - - - -	0·1790 "

	I.	II.	III.	IV.	Theory.
C,	13·46		13·52		13·41
H,	2·89		2·80		2·78
Cl,		59·07			59·33
Si,				15·27	15·58

The vapor-density =6·378; theory 6·216.

Difference between two weights of bulb, -	0·9317 gr.
Temperature of the balance, - - -	22°·5
" " oil-bath, - - -	163°·5
Barometric pressure, - - - -	766·6 mm.
Capacity of bulb, - - - - -	231·5 cc.
No air remaining.	

The density at 0° =1·291.*

The boiling points of the above compounds, in which a portion of the atoms of the peroxyd of ethyl are replaced by chlorine, represent a series, in which the secondary differences are nearly constant.

Silicate of ethyl, - -	165°·5		
Monochlorhydrine, - -	157	8°·5	11°·5
Dichlorhydrine, - - -	137	20	13
Trichlorhydrine, - -	104	33	12
Chlorid of silicium, -	59	45	

Triethylic monoamylic silicic ether.—The monochlorhydrine served to prepare this mixed ether, which is nothing else than a normal ethylic silicate, in which one atom of ethyl is replaced by amyl. To obtain it, it is sufficient to bring together a molecule of monochlorhydrine and one of amylic alcohol. The reaction takes place immediately with evolution of HCl.

$$3\left(\begin{matrix}Si\\ C_2H_5\\ Cl\end{matrix}\right\}\Theta_3 + \left.\begin{matrix}C_5H_{11}\\ H\end{matrix}\right\}\Theta = 3\left(\begin{matrix}Si\\ C_2H_5\\ C_5H_{11}\end{matrix}\right\}\Theta_4 + HCl.$$

The liquid commenced to distil at 205°, and almost all passed below 230°. The greater part boiled at 216°–225°. The analysis of different products gave—

* The density of chlorid of silicium at the same temperature we determined =1·522.

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I.	(Boiling point 216°–225°.)	Substance, wt.,	0·2875 gr.
		CO_2, -	0·5560 "
		H_2O, -	0·2620 "
II.	(Boiling point 223°–230°.)	Substance, wt.,	0·7015 "
		SiO_2, -	0·1625 "
III.	(215°–220°.)	Substance, wt.,	0·2215 "
		CO_2, -	0·4280 "
		H_2O, -	0·2070 "
IV.	(215°–220°.)	Substance, wt.,	0·3845 "
		SiO_2, -	0·0940 "

Another preparation where an excess of amylic alcohol had been employed—

V.	(214°–220°.)	Substance, wt.,	0·3795 gr.
		CO_2, -	0·7480 "
		H_2O, -	0·3640 "

	I.	II.	III.	IV.	V.	Theory.
C,	52·74		52·73		53·78	52·80
H,	10·13		10·38		10·75	10·40
Si,		10·80		11·40		11·20

Analysis number V, and those of products boiling above 230°, indicated the presence of a mixed ether, containing more amyl than the one we sought to obtain. This fact awakened our attention, and induced us to make some researches on the action of alcohols upon the ethers of acids, which showed us that an alcohol can act directly upon an ether and that an interchange of the two radicals takes place;* thus when an excess of amylic alcohol is employed, it acts upon the triethylic mono-amylic silicic ether and an ether containing more amyl is formed.

Triethyl monoamyl silicic ether is a colorless, somewhat oily liquid, with a feeble odor like that of all amylic compounds. It is not entirely decomposed by treatment with an alcoholic solution of ammonia, and it is necessary to employ a solution of caustic soda in alcohol to make the determination of silica. Ebelmen made the same observation in regard to the silicate of amyl. Density at 0°=0·926.

The mixed ether on distillation, even in vacuo, has a tendency to decompose with formation of diamylic diethylic ether, and doubtless at the same time of normal ethylic silicic ether. A product which had been prepared from the monochlorhydrine without an excess of amylic alcohol, after several distillations at 100°–110°, under a pressure =3–5 millemeters of mercury, had a composition between that of the mono- and the di-amylic mixed ether.

Substance, weight, - -	0·2805 gr.
CO_2, - - - -	0·5640 "
H_2O, - - - -	0·2750 "

* This Journal, xl, 34.

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	I.	$Si,3(C_2H_5),(C_5H_{11})O_4$.	$Si,2(C_2H_5),2(C_5H_{11})O_4$.
C,	54·88	52·80	57·53
H,	10·91	10·40	10·96

Diethylic diamylic silicic ether was prepared in the same way as the preceding by treating the dichlorhydrine with amylic alcohol. The portion boiling at 245°–250° was analyzed.

I.	Substance, weight,	0·2115 gr.
	CO_2,	0·4495 "
	H_2O,	0·2095 "
II.	Substance, weight,	0·3980 "
	SiO_2,	0·0780 "

	I.	II.	Theory.
C,	57·89		57·53
H,	10·99		10·96
Si,		9·15	9·59

The density at 0°=0·9150.

Monoethylic triamylic silicic ether was obtained in the same way as the preceding with the trichlorhydrine and amylic alcohol. It boils at 280°–285°.

I.	Substance, weight,	0·2410 gr.
	CO_2,	0·5350 "
	H_2O,	0·2425 "
II.	Substance, weight,	0·4820 "
	SiO_2,	0·0875 "

	I.	II.	Theory.	$SiC_{17}H_{38}O_4$.
C,	60·51		61·08	
H,	11·18		11·37	
Si,		8·47	8·38	

This ether resembles in its properties the silicate of amyl. The density at 0°=0·913.

All these mixed ethers can only be prepared from the pure chlorhydrines, as they are decomposed on distillation, and therefore cannot be purified in that way.

Polysilicates of ethyl.—Ebelmen describes, besides the normal silicate, two others, the one containing twice as much silicic acid, and the other four times as much, and calls them bisilicate and quadrisilicate of ethyl.

He obtained the bisilicate, to which he gives the formula

$$2SiO, C_4H_5O \quad (Si=7, C=6, O=8, H=1),$$

by treating the chlorid of silicium with alcohol containing one equivalent (16 per cent) of water. One equivalent of alcohol was added to two equivalents of chlorid.

To quote his memoir, "when the product is distilled, the temperature of the liquid, contained in the retort, rises from 160° to 350° without a considerable quantity of the product distilling.

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At this moment the mercury thermometer is taken away, the receiver is changed, and on continuing to heat, soon an abundant colorless product passes. * * * The liquid, distilled above 350°, was rectified with a thermometer placed in the retort; a very small quantity of a product, which distilled below 350°, was collected by itself, then the thermometer was removed, and the distillation continued, and in a few instants almost the whole contents of the retort passed over into the receiver. It did not appear doubtful to me, that a body, which distills with so great rapidity could be other than a definite product, having a fixed boiling point near 350°." According to Ebelmen the bisilicate can also be obtained by adding to the protosilicate alcohol, containing the requisite quantity of water.

As for the quadrisilicate, he says that it is obtained by adding a little aqueous alcohol to the bisilicate, and remains in the retort after the distillation of the latter. It appears to be decomposed into bisilicate and silica at a temperature a little above that at which the bisilicate distills. The existence of these two ethers, if we give them the formulæ

$$\left.\begin{matrix}\mathrm{Si}\\ 2(\mathrm{C}_2\mathrm{H}_5)\end{matrix}\right\}\Theta_3 \quad \text{or} \quad \left.\begin{matrix}2\mathrm{Si}\\ 4(\mathrm{C}_2\mathrm{H}_5)\end{matrix}\right\}\Theta_6 \quad \text{and} \quad \left.\begin{matrix}2\mathrm{Si}\\ 2(\mathrm{C}_2\mathrm{H}_5)\end{matrix}\right\}\Theta_5,$$

accords perfectly with what is known of the formation of condensed bodies. Wurtz* has observed the formation of polyethylenic alcohols, which are nothing but the anhydrids of glycol, anhydrids formed by the condensation of several molecules into a single one. He has since 1862† applied to the hydrates of silicic acid the same theory, by means of which he explained the formation of polyethylenic compounds. Wurtz and Friedel‡ have shown that the theory of condensations is applicable to acids as well as to alcohols, and several researches, among others those of Hugo Schiff,§ have confirmed this view. It results from this, that if, in order to take the most simple case, we take the hydrate of silicium, corresponding to the chlorid, in which the 4 atoms of chlorine are replaced by 4 equivalents of the body HΘ,

$$(1.) \qquad \mathrm{Si}\left\{\begin{matrix}\Theta\mathrm{H}\\ \Theta\mathrm{H}\\ \Theta\mathrm{H}\\ \Theta\mathrm{H}\end{matrix}\right. = \mathrm{Si}, 4(\Theta\mathrm{H}).$$

We can derive from this hydrate, which with Odling we call normal, the following hydrates containing less water.

First, without condensation:

* Bulletin de la Société Chimique, [1], i, 82; December, 1859.
† Répertoire de Chimie pure, ii, 449.
‡ Ann. de Chim. et Phys., [3], lxiii, 111; 1861.
§ Comptes Rendus de l'Académie des Sciences, liv, 1075; 1862.

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$$\text{(2.) 1st anhydrid,}\quad \mathrm{Si}\left\{\begin{matrix}\mathrm{O}\mathrm{H}\\ \mathrm{O}\\ \mathrm{O}\mathrm{H}\end{matrix}\right. = \mathrm{Si}, \mathrm{O}, 2\mathrm{O}\mathrm{H}.$$

The silicate which Odling calls metasilicate corresponds to this hydrate.

Secondly, with condensation:

$$\text{(3.) 1st anhydrid,}\quad \begin{matrix}\mathrm{Si}\left\{\begin{matrix}\mathrm{O}\mathrm{H}\\ \mathrm{O}\mathrm{H}\\ \mathrm{O}\mathrm{H}\end{matrix}\right.\\ \mathrm{O}\\ \mathrm{Si}\left\{\begin{matrix}\mathrm{O}\mathrm{H}\\ \mathrm{O}\mathrm{H}\\ \mathrm{O}\mathrm{H}\end{matrix}\right.\end{matrix} = 2(\mathrm{Si}\mathrm{O}), 6(\mathrm{O}\mathrm{H}).$$

This hydrate is the type of Odling's intermediate silicates, bodies which it would be better to call disilicates.

$$\text{(4.) 2d anhydrid,}\quad \begin{matrix}\mathrm{Si}\left\{\begin{matrix}\mathrm{O}\mathrm{H}\\ \mathrm{O}\mathrm{H}\\ \mathrm{O}\mathrm{H}\end{matrix}\right.\\ \mathrm{O}\\ \mathrm{Si}\left\{\begin{matrix}\mathrm{O}\\ \mathrm{O}\mathrm{H}\end{matrix}\right.\end{matrix} = 2\mathrm{Si}, 2\mathrm{O}, 4(\mathrm{O}\mathrm{H}).$$

$$\text{(5.) 3d anhydrid,}\quad \begin{matrix}\mathrm{Si}\left\{\begin{matrix}\mathrm{O}\mathrm{H}\\ \mathrm{O}\end{matrix}\right.\\ \mathrm{O}\\ \mathrm{Si}\left\{\begin{matrix}\mathrm{O}\\ \mathrm{O}\mathrm{H}\end{matrix}\right.\end{matrix} = 2\mathrm{Si}, 3\mathrm{O}, 2(\mathrm{O}\mathrm{H}).$$

Without giving other formulæ of possible hydrates, we will observe, that the three ethers of Ebelmen would come under the case (1), (2) or (4) and (5). Ebelmen does not speak of any ether corresponding to the formula (3), but this is the only one that we have been able to obtain in a state of purity, and every repetition of Ebelmen's experiment has given negative results, in spite of the most persevering efforts to prepare his bisilicate and quadrisilicate.

Hexethylic disilicic ether.—Having operated upon several pounds of chlorid of silicium, and prepared large quantities of silicate of ethyl with alcohol, which was not perfectly anhydrous, a considerable portion of the product boiled at a higher temperature than the normal silicate. We collected all the products of different preparations, and on submitting them to a fractionated distillation, we observed that a much larger amount of liquid distilled at about 240°, than at any other point above or below between 170° and 320°. In one preparation where 800 grams of chlorid of silicium were employed, we obtained, beside the normal silicate, 80 grams of a product boiling at 230°–240°. An analysis gave:

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I.	Substance, weight,	0·3860
	CO_2,	0·5940
	H_2O,	0·3100

Not succeeding well at first in obtaining a compound boiling at a fixed temperature, we submitted all the products, whose boiling point was higher than that of the normal silicate, to a series of distillations in vacuo. This operation can be conducted without difficulty, thanks to the tubes and corks of india-rubber now manufactured,* and the labor of working the air-pump during several days in succession was rendered much less disagreeable by the employment of one of Bianchi's rotary pneumatic machines, with the aid of which we could maintain an atmosphere exercising a pressure equal to only 3–5 millimeters of mercury during all the operations.

After eight fractionated distillations (pressure 3–5 mm.), the product distilling at 125°–130° was analyzed.

II.	Substance, weight,	0·7260
	Silica,	0·2550
III.	Substance, wt. (boiling point =126°–130°),	0·3675
	CO_2,	0·5690
	H_2O,	0·2970

This portion (125°–130° in vacuo), distilled in the air, passed almost entirely at 233°–238°. An analysis of this gave:

IV.	Substance, weight (boiling point 233°–238°),	0·1775
	CO_2,	0·2745
	H_2O,	0·1395
V.	Substance, weight,	0·3750
	SiO_2,	0·2005

	I.	II.	III.	IV.	V.	VI.	VII.	Theory. $2Si, 6(C_2H_5), 7O$.
C,	41·96		42·22	42·16				42·11
H,	8·92		8·97	8·74				8·77
Si,		16·38			16·28	16·53	16·59	16·38

All these numbers agree with the formula $\left.\begin{matrix}Si_2\\(C_2H_5)_6\end{matrix}\right\}O_7$, which belongs to one of the ethers of disilicic acid, if this name be given to the hydrate, which results from the condensation of two molecules of the normal hydrate with elimination of the smallest quantity possible of water, i. e., one molecule.

The reaction which gives rise to the ether above analyzed is expressed by the equation

$$2\left[\left.\begin{matrix}Si\\(C_2H_5)_4\end{matrix}\right\}O_4\right]+H_2O=\left.\begin{matrix}Si_2\\(C_2H_5)_6\end{matrix}\right\}O_7+2\left(\begin{matrix}C_2H_5\\H\end{matrix}O\right).$$

* Vulcanized india-rubber becomes less pervious to air after it has been boiled with a weak solution of caustic potash sufficiently long to extract most of the sulphur.

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As this ether, which may be named hexethylic disilicic ether, was not obtained by Ebelmen, we have used great care in assuring ourselves, that it is really a distinct compound, and rely as proof upon the following facts. The boiling point after repeated distillations remains constant at a temperature too remote from that of the boiling points, which Ebelmen indicates for the normal ether and for his bisilicate, to make it possible to consider it as a mixture of these two compounds. We succeeded in obtaining the ether almost pure by treating chlorid of silicium with alcohol containing the requisite quantity of water. The product of this experiment was distilled under a pressure of 3–5 mm., and distilled almost entirely at 126°–130°.

This product, boiling at 126°–130° in vacuo, furnished the material for the determinations of silica VI and VII given above.

VI.	Substance, weight,	0·7305
	SiO_2,	0·2585
VII.	Substance, weight,	0·9370
	SiO_2,	0·3330

We thought at first that the compound was decomposed by heat, and that its boiling point changed after a large number of distillations in the air, and this indeed was the reason, that we undertook the series of distillations in vacuo; but this idea proved afterwards to be erroneous, for a portion, distilled in vacuo after having been heated seven hours at 230°–235° in a sealed tube did not change its boiling point. With silicic ethers as with the chlorhydrines great care must be taken to exclude the moisture of the atmosphere during the protracted operations necessary to effect a large number of fractionated distillations, and if the boiling points changed, it was because the ethers had been decomposed by moisture.

The vapor density of hexethylic disilicic ether corresponds with the formula given above. The first determination was made with an impure product, and the number 13·5 instead of 11·86 was found; but this only came from a portion of an ether having a higher boiling point, which remained in the bulb. This we satisfied ourselves of by making a determination of silicic acid of the liquid remaining in the bulb.

I.	Substance, weight,	0·8875
	SiO_2,	0·3205

Si=16·82 instead of 16·38, the theoretical number. If we suppose that the excess of silica came from an admixture of a body having the composition of the bisilicate of Ebelmen, the liquid remaining in the bulb must have contained one-tenth its weight of that compound.

A second determination made with a product redistilled several times and boiling at 233°–234° gave 12·025, a number which corresponds very closely with the theoretical 11·86.

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Difference between the weights of bulb,	1·6595 gr.
Temperature of balance, - - -	12°·5
" " oil-bath (mercury thermom.),	296°
Height of barometer, - - - -	757·8 mm.
Capacity of bulb, - - - - -	320 cc.
Air remaining (measured), - - -	26 cc.

11° temperature and 756·8 mm. barometric height.

A determination of silica was made from the liquid remaining in the bulb.

Substance, weight, - -	0·4670
SiO_2, - - - - -	0·1655

Si=16·48; theory=16·38. The density of the hexethylic disilicic ether is at 0° =1·0196, at 19°·2 =1·0019.

The ether is a colorless liquid of slightly oily consistency, with a rather agreeable odor, scarcely differing from that of the normal silicate. It burns with a smoke composed of silicic acid like all of this class of compounds.

Aqueous alcohol transforms it into products having a higher boiling point. It is not so easily acted on by moisture as the normal silicate.

After we had demonstrated the existence of the above body we attempted to obtain the bisilicate of Ebelmen in order to determine whether it corresponds to the first anhydrid of silicic acid or to the second anhydrid of disilicic acid, if this latter exists; but all the experiments undertaken failed to give this body, whose existence seemed so probable on theoretical grounds and whose preparation seemed so easy according to the statements of Ebelmen. We have submitted to a great number of fractionated distillations in the air, under a diminished pressure and in vacuo, the products boiling above 240°, without being able to observe any point, at which a particularly large quantity distilled; and it will be seen by our analyses, that the quantity of silicic acid contained in the higher products, was greater than that required by theory for the bisilicate of Ebelmen. The temperature also, which was measured in vacuo by a mercury thermometer, corresponds to 450° in the air, a point much higher than that at which Ebelmen supposed his compound to boil. It may be of use to give the results of our experiments as they teach us something concerning the nature of the condensed silicates containing more silicic acid than the ether just described.

In order to determine the difference in boiling point due to a diminution of pression, and to ascertain what reliance could be placed on the constancy of boiling points in vacuo, we distilled, under a pressure of 3–5 millimeters, the normal silicate of ethyl having a fixed boiling point at 165°·5 in the air. Platinum wire and a piece of charcoal were put in the flask to make the ebullition as quiet as possible, but without any very marked effect.

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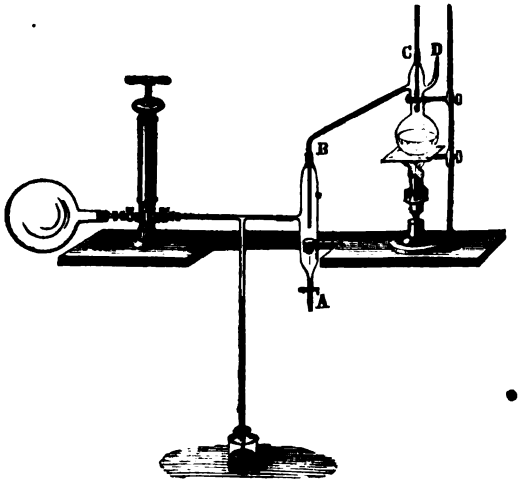
The normal ether began to boil at 55° and the thermometer rose rapidly to 72°–73° and remained nearly stationary at this temperature (in another experiment at 74°–75°) during the distillation. When the distillation was interrupted and recommenced, ebullition commenced always at a much lower point than 73°. According to this, the diminution of pressure to 3–5 mm. lowers the boiling point of the ether in question from 165°·5 to about 73°. We have seen that the hexethylic disilicic ether, which distilled at 233°–8°, in the air distilled at 226°–230° under a pressure of 3–5 mm. For this latter product, the limits of temperature within which the thermometer varies during a distillation in vacuo, are much less than for normal ether.

The ebullition is much more regular under a somewhat greater pressure, and for this reason and also because we hoped that the change of pressure might facilitate the separation of the products, as Roscoe has observed in the case of hydrates of acids, we made another series of distillations under a pressure of 60 millimeters of mercury.

These distillations were made with an apparatus which permitted us to operate almost as rapidly as when distilling in the air, and it only requires a small hand pump, when no better is to be procured.



The opening B has an india-rubber tube through which is passed the glass tube leading from the flask containing the substance. At C a thermometer is introduced in the same way. The lower end, A, of the receiver has a tube, which is closed during the distillation, and is opened to draw off the product when required. It is not necessary to surround the receiver

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with water, as the specific heat of the silicic ether is very small. The opening D, which is closed with a piece of glass rod fitting into an india-rubber tube, serves to add a new quantity of liquid when required. The object of the other parts of the apparatus is obvious. The balloon at the extremity only serves to augment the volume, so that a constant pressure may be more easily obtained; its communication with the distilling apparatus is closed when it becomes necessary to open the latter. All the connections were made with india-rubber tubes boiled in potash, and used double, the inner one coated with tallow, and when the apparatus was left to itself the pressure only varied a few millimeters in twenty-four hours, and could easily be kept perfectly constant by a few strokes of the air pump during a distillation. We will give the results of several series of distillations made with the same material under different pressures.

[To be concluded.]

ART. XVIII.—*Remarks on the Cretaceous rocks of the West known as No.* 1, *or the Dakota Group;* by F. V. HAYDEN.

THE Cretaceous rocks of the Upper Missouri have been separated into five divisions, which have been designated, for the sake of convenience, by Nos. 1, 2, 3, 4, and 5.* They have also received special geographical names indicating points where they are shown in their largest development.† The Dakota group or Formation No. 1, lies at the base of this series, and either as an outcropping or underlying rock extends over a large portion of Nebraska, Dakota, Minnesota, Kansas, and even reaches far southward into New Mexico. It is more distinctively defined along the Missouri river between Omaha City and the Big Sioux, where it exhibits its typical characters.

The lithological characters of this group have been so often described in former memoirs by Mr. Meek and the writer, that they scarcely need to be repeated here. The principal object of this article is to present such additions to our knowledge of it as may have been obtained since our last papers were published. It is not intended to discuss in detail any differences of opinion, or to make any criticisms, but to present certain facts and statements gathered by Professors Capellini and Marcou in their tour to Nebraska in 1863, and the results of the investigations of Prof. Heer derived from the study of the flora of this group.

* Memoirs Am. Acad. Arts and Sci., vol. v, new series, also numerous papers by F. B. Meek and F. V. Hayden.

† Proceedings Acad. Nat. Sci., Dec. 1861.

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In order that the geological relations of the Dakota group may be better understood, I have given a brief summary of the contiguous formations.

In ascending the Missouri river we find near Fort Leavenworth exposures of limestone which, up to the present time, we have regarded as belonging to the upper Coal-measures. The beds are all nearly horizontal, with a slight, almost imperceptible, dip toward the northwest. As we continue up the Missouri, layer after layer of these Coal-measure rocks pass from view beneath the water level of the river, and when we reach Fort Lisa they have entirely passed from sight and are overlapped by a bed of variegated friable sandstone. The sandstone undoubtedly exists, or has existed, as an underlying rock considerably lower down the river than Fort Lisa, probably nearly to Omaha City, but has either been removed by erosion, or concealed by the great thickness of superficial recent deposits which cover this country, sometimes entirely hiding from view the underlying basis rocks over large areas. Ascending the Platte valley we have the true Upper Carboniferous limestone nearly to the mouth of the Elkhorn. Before reaching that point, however, we observe a portion of No. 1 resting directly upon the limestones, as the following section will show.

1. Gray compact siliceous rock, passing down into a coarse conglomerate, an aggregation of water-worn pebbles, cemented with angular grains of quartz; then a coarse grained micaceous sandstone (lower portion of Dakota group), 25 feet.

2. Yellow and light gray limestone of the upper coal-measures containing numerous fossils, *Spirifer cameratus*, *Spirigera subtilita*, *Fusulina cylindrica*, *Productus*, *Chonetes*, and abundant coral and crinoidal remains.*

At the mouth of the Elkhorn, the Carboniferous limestones have passed from view beneath the Cretaceous sandstones. The intermediate Permo-carboniferous and Permian rocks, as well as the variegated and gypsiferous marls and clays which are quite conspicuous westward from Fort Riley, are wanting in this region. The Dakota group as seen along the Missouri passes beneath the bed of the river about 30 miles above the mouth of the Big Sioux. How far up the Big Sioux it extends is not yet known; but at a point 40 miles up the valley, the seam of earthy Lignite, which is seen just above the Omaha reserve, crops out, and is exciting some attention among the farmers.

The researches of Prof. Hall have extended this group northward from the Missouri river into Minnesota 130 miles or more. In an interesting memoir read before the American Philosophical Society at Philadelphia, Prof. Hall, after describing numerous exposures of the variegated quartzites from St. Peters to Fort

* Trans. Amer. Phil. Soc. 1861.

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Ridgely, says: "Proceeding westward from Fort Ridgely, I had no opportunity of seeing any other formation than the prairie for about thirty miles. At this point near where we crossed the Big Cottonwood River, there is an exposure of rock in the bank of the stream; and at a short distance farther on, some explorations had been made for coal, and a shaft had been sunk to the depth of more than one hundred feet. The materials thrown out of this shaft consisted of a dull greenish argillaceous sand, with calcareous nodules, together with irregularly laminated sandstone containing vegetable remains. The order of deposits, as given to me by Mr. Morin, who superintended a part of the working, was as follows:

1. Ironstone; 1 ft. 6 inches.
2. Sand, clay, etc.; 40 ft.
3. Earthy coal;* 1 ft. 8 inches.
4. Sand, clay, etc.; 3 ft.
5. Sandstone in irregular and diagonally laminated layers, with sometimes calcareous concretions, and containing plant remains; 5 ft.
6. A Calcareous sandy clay of variable color and character; 20 ft.
7. Sandstone in loose thin layers of three or four inches; 4 ft.
8. Clay with coaly seams near the bottom; 16 ft.
9. Clay; 13 ft.
10. Loose quicksand to bottom of shaft.

"In the river bank, at a quarter of a mile distant, and at a level 30 or 40 feet below the ground where the shaft began, there is the following exposure:

1. Loose ironstone† in nodules and irregular concretions, more or less mixed with drift and pebbles; 1–2 ft.
2. Calcareous clay; 6–8 ft.
3. Earthy coal; 8 inches.
4. Clay as above coal; 4 inches.
5. Yellow or ferruginous sand and clay; 3–3½ ft.
6. Ferruginous sandstone in irregular layers and diagonally laminated to level of river; thickness unknown.

"This sandstone appears to be the same as that containing the vegetable remains met with in the shaft; and though I did not find plants in it at this point, I was informed that specimens had been found there; and at another place on the Cottonwood I found them to be quite common. Near the previous exposure,

* An analysis of this coal, by Prof. T. Sterry Hunt, gave the following results:

Fixed carbon, ...	26·1
Volatile "	25·7
Ash "	48·2=100·0

In the sections of strata near the mouth of the Redwood river, there is a stratum of similar earthy coal three feet thick.

† This ferruginous layer does not appear to belong to the regularly stratified deposits, as it overlies, irregularly, the edges of the successive beds, and has been deposited after the denudation had taken place.

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and partly from an old digging, I obtained a similar section. At still another point I noticed a similar exposure, leaving no doubt of the character and order of arrangement of the materials composing this formation.

"The character of the vegetation obtained from the sandstone of the shaft and elsewhere, resembling the leaves of Salix, Poplar, Liriodendron, Tupelo, etc., induced me to refer this formation to the Cretaceous period. A single indistinct shell was the only animal fossil I was able to obtain. In aspect the calcareous concretions are similar to those from the Cretaceous formation of the upper Missouri; and the green argillaceous clay is likewise similar."

At Redwood Falls, also, Prof. Hall obtained another section of this group with a seam of earthy coal three feet in thickness. There is little doubt that this group will be found extending far northward, either as a continuous formation or in isolated patches, perhaps even into the British possessions.

In September, 1863, Mr. Marcou and Prof. Capellini of the University of Bologna, Italy, made an excursion up the Missouri river to a point near the mouth of the Big Sioux. It seems that both of them studied with care the different geological formations along the river under quite favorable circumstances. Prof. Capellini made quite an extensive collection of fossil plants at different localities, principally from Tekama, Blackbird Hill and Big Sioux. These plants he placed in the hands of Prof. O. Heer of the University of Zurich, Switzerland, who described them in a small but carefully prepared memoir with four plates, 4to. Mr. Marcou also published the results of his examinations in the Bulletin of the Geological Society of France. He there acknowledges that the rocks, which have hitherto been included in No. 1 or Dakota group are Cretaceous. Capellini and Heer came to the same conclusion, and thus one disputed point in regard to the geology of the West may be regarded as forever set at rest. I would remark just here, that I have personally examined the greater part of the territories of Kansas, Nebraska, Dakota, Montana, Idaho, and Colorado, and I feel confident that, although future investigations may perhaps modify, they will not essentially change, the published results.

After examining the Carboniferous limestones as far as Bellevue, Nebraska, Mr. Marcou* continued up the Missouri and examined the sandstones of the Dakota group. In this red sandstone he found a rich flora of well preserved leaves of Laurel, Poplar, Sassafras, Walnut, Oak, Willow, Tulip, a flora which

* Reconnaissance géologique au Nebraska, par Jules Marcou: Extrait du Bulletin de la Société Géologique de France, 2d série, t. xxi, p. 132, Jan. 18th, 1864, and Les Phyllites Crétacees du Nebraska, par MM. les Prof. J. Capellini et O. Heer, tirage a part des Mémoires de la Société Helvétique des Sciences Naturelles.

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Prof. Heer regards as Miocene, and has more the aspect of upper Miocene or even Pliocene than of the lower Tertiary epoch. Nevertheless, the flora is not even Tertiary but really lower Cretaceous. It is found in a fresh-water formation at the bottom of the White Chalk of the Missouri Basin. It was Dr. Hayden who first collected these dicotyledonous plants at Blackbird Hill, at the Omaha Mission, where a quarry was opened for the purpose of erecting the mission house. Mr. Heer who saw the designs of the first collection made at Blackbird Hill by Dr. Hayden, declares that this flora is not Cretaceous, but that on the contrary it has a very close analogy with the lower Miocene or Oligocene of Europe. But notwithstanding these facts, Mr. Marcou saw superimposed upon the rocks with dicotyledonous leaves at Pilgrim Hill and on the banks of the Big Sioux, beds of chalk containing *Inoceramus problematicus*, *Ostrea congesta*, &c., and that too without any indications of faults or disturbances of strata. "I yield to the opinion of Mr. Hayden and regard these beds as Cretaceous. But I make one reservation; that all the Cretaceous beds of Nebraska, and of the upper Missouri in general, are very recent and correspond, as also those of New Jersey, to the Senonien of d'Orbigny, and perhaps also to his Turonien."

From his observations in Nebraska, Mr. Marcou arrives at the following conclusions.

1. "The rules and laws of paleophytology hitherto adopted and followed must be greatly modified, since we find here a flora, regarded as Miocene in Europe, at the base of the Chalk period. On this account I may be permitted to add that, in the geographical distribution of the existing flora, I have discovered contrasts much greater than those in the distribution of the existing fauna. One of these contrasts which surprised me most is that of the elevated plateaus of New Mexico, Texas, Arizona and California, which is certainly more different from the flora of the States bordering upon the Atlantic and the basin of the Mississippi under the same conditions of temperature and latitude, while on the other hand it does not differ from the Tropical flora of Florida, the Antilles and Panama. After this discovery I could see no serious objection which would have weight in the mixture of Carboniferous plants and Belemnites at Petit-Couer in Laventaire, since in Nebraska we have Miocene plants underneath 500 or 600 feet of white chalk containing *Inoceramus*, *Ammonites*, and *Baculites*.

2. "The new red sandstone and more especially the lower portion or dyas occupies a very important place in the geology of Nebraska, as I announced it in 1855 to the Geological Society of France, in my geological chart of the United States and in the explanatory résumé which accompanied it.

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3. "The dyas of Nebraska is composed of two members, as in Russia and Germany, one of which corresponds to the Rothliegende and the other to the Zechstein."

Prof. Capellini in a short but very interesting article confines his observations mostly to the rocks of the Dakota group and remarks that he does not hesitate to regard the observations of American geologists as entirely just. The following remarks close the article of Prof. C.

"After all we have observed in relation to the environs of Sioux City, it is easily seen that a stratigraphic series so complete throws a clear light upon the isolated facts first noticed at Tekamah and Blackbird Hill, and indicates the exact position of the rocks with dicotyledonous leaves, analogous to the Tertiary leaves of Europe but belonging in reality to the Chalk.

"It may be estimated that the thickness of these Cretaceous strata in the environs of Sioux City is about 40 meters. They may be divided into two distinct parts, one rich in leaves, a fresh-water formation; the other truly chalky with fishes and Inoceramus, of marine origin—both are probably not older than the chalk of Maestricht. This has been my opinion from the time I admitted that the dicotyledonous leaves of the Big Sioux and Tekamah were Cretaceous.

"Once the age of the Mollasse with leaves established by the aid of the stratigraphy and the animal fossils, it would be interesting if it were possible to arrive at the same results by the vegetable remains. On this account, Prof. Heer came to my aid and investigated the specimens I collected in my explorations. More than a dozen species were recognized among the leaves from Tekamah, Blackbird Hill, and Big Sioux, but it was especially the first locality which furnished the best specimens. We are convinced that when observations are exact and determinations made from careful examination of specimens, there is never any disagreement between stratigraphical and paleontological laws."

The remarks of Prof. Heer which preface his descriptions of the fossil plants collected by Prof. Capellini, are so interesting and important that we copy them entire.

"The collection of Mr. Capellini contains 16 species; 4 are badly preserved; 12 are determinable. Nevertheless, of the latter, several are but fragments, so that their determination is difficult and not sufficiently positive. This is especially the case with the Phyllites which I have referred to the genera Platanus and Andromeda. It is certain that all the leaves found by Mr. Capellini are dicotyledons and with great probability one may be referred to the genus Ficus, one to Salix, one to Diospyrus, two to Populus and two to Magnolia, although there are no accompanying fruits or other parts to confirm these determina-

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tions. These genera are yet living and they are also found in the Tertiary formations.

"If we compare these plants of Nebraska with the Cretaceous plants of Europe, we find no identical species among them. I sent drawings of them to Dr. Debey of Aix la Chapelle, who discovered in that locality a Cretaceous flora. He has written to me that he has not found one species identical. Even the greater part of the genera are different. There is but one Cissites (*C. aceroides* Debey) which recalls slightly the *C. insignis* (Plate IV, fig. 5). The Cretaceous plants of Henant, Belgium, those of Blankenburg and Quedlinburg are also very different.

"Prof. Schenk has recently sent to me, a collection of plants of Quedlinburg for determination. Besides conifers and ferns characteristic of the chalk, it contains dicotyledons, but no forms like those of Nebraska.

"The Cretaceous flora of Moletein, Moravia, which I have lately studied, exhibits more resemblance. It contains two species of Ficus which much resemble the Ficus of Nebraska, two superb species of Magnolia, one with a fruit cone. There is a relationship between the flora of Nebraska and that of the upper Chalk of Europe, although identical species are wanting. But to the present time no characteristic genus of the Cretaceous flora of Europe has been found in Nebraska.

"If we compare the plants of Nebraska with the Tertiary plants we find no identical species, but 7 genera, (Populus, Salix, Ficus, Platanus, Andromeda, Diospyrus and Magnolia) are also Miocene and likewise living. It then appears that the Nebraska flora is related more to the Tertiary than to the Cretaceous flora of Europe, a fact which struck me when I first saw drawings of the former. But it should be remarked that we know but a very small number of American species, and on the other hand, the European Cretaceous flora has more relationship with the Tertiary flora than I at first supposed. I have found in the Cretaceous flora of Moletein, Moravia, species of Ficus and Magnolia which resemble Tertiary species; a Myrtacea, which is a near neighbor to the *Eucalyptus rhododendroides*, Mass, of Mt. Bolca; a Juglans and a Laurinea, which also have their analogues in the Tertiary flora; a Pinus and two other conifers which belong to the genus Sequoia, which was extensively distributed in Europe and America in the Miocene epoch and which is now only found in California.

"As the Cretaceous fishes are more nearly related to the Tertiary than to the Jurassic fishes, the upper Cretaceous flora is also entirely different from the Jurassic and more nearly allied to the Tertiary floras, and it appears that in America the relation between the Tertiary and Cretaceous flora is yet more intimate than in Europe.

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"It is remarkable that the plants of Nebraska (as Magnolia and Liriodendron) present relations with the existing flora of America, whilst the Cretaceous flora of Europe has more of an Indo-Australian character. It thus appears that since the Cretaceous epoch, the American flora has not undergone a change so great as the European flora. While the Cretaceous flora of Europe is entirely different from the existing European flora, that of Nebraska contains 8 genera yet found in America, and it is the more remarkable that the greater part are yet found in a country under the same latitude."

Prof. Heer describes the following species of plants from this group in this memoir: *Populus litigiosa*, *P.? Debeyana*, *Salix nervillosa*, *Betulites denticulata*, *Ficus primordialis*, *Platanus? Newberryana*, *Proteoides grevilleæformis*, *P. daphnogenoides*, *P. acuta*, *Aristolochites dentata*, *Andromeda Parlatorii*, *Diospyrus primæva*, *Cissites insignis*, *Magnolia alternans*, *M. Capellini*, *Liriodendron Meekii*, *Phyllites Vanonæ*.

Both Mr. Marcou and Prof. Capellini agree in regarding this sandstone in which the dicotyledonous leaves are found as a fresh-water formation. I would simply say that I have always regarded it as marine and I am sure this has been the opinion of my friend Mr. Meek. At any rate we have found mingled with the leaves at Sioux City quite well preserved casts of *Pharella? Dakotaensis*, *Axinæa Siouxensis* and *Cyprina arenacea*, shells peculiar to marine deposits.

The question has arisen, whether this period had a fauna corresponding to its flora? Besides the Mollusca already alluded to, no remains of land animals have yet been discovered which could be positively identified. On the eastern slope of the Big Horn mountains, I saw in 1859, a series of beds holding a position between No. 2 Cretaceous and the Jurassic rocks below, which I referred without hesitation to this group. In these rocks were beds of earthy Lignite, large quantities of petrified wood, and numerous large uncharacteristic bones which doubtless belong to some Saurian. No remains of strictly land animals have ever been found.

Although I have endeavored to give the substance of Mr. Marcou's memoir in this article, I do not wish to be regarded as endorsing all that he has said in regard to the existence of "Dyas" and "Mountain limestone." In the autumn of 1856, while descending the Missouri river, I saw some peculiar local beds near St. Stephen's, Nebraska, from which I obtained *Myalina perattenuata*, *Pleurophorus occidentalis* and *Lyonsia concava*, which were sufficient to indicate that they were either Permian or the transition beds which we have called Permo-carboniferous. These questions have been most ably and exhaustively discussed by Mr. F. B. Meek in an article in this Journal, Jan., 1866, to

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which the reader is referred. The main object of the present article is to place before those American readers of this Journal, who may not have access to foreign Journals, such views and important geological facts as Profs. Marcou and Capellini obtained in their field investigations, as well as those of Prof. Heer from the study of the fossil plants.

University of Pennsylvania, Philadelphia, Jan. 8th, 1867.

ART. XIX.—*Researches on Solar Physics;** by WARREN DE LA RUE, Esq., Pres. R.A.S., BALFOUR STEWART, Esq., Superintendent of the Kew Observatory, and BENJAMIN LOEWY, Esq., Observer and Computer to the Kew Observatory.

First Series.—On the Nature of Sun-spots.

1. THERE is a marked difference between our luminary and our satellite, as far as regards our knowledge of their physical aspect and constitution. Many parts of our own globe are not so well known, or so correctly mapped, as certain regions in the moon; and could we imagine an observer transported into the neighborhood of Tycho or Copernicus, he would probably be better prepared for the appearance presented to him, than he would be if placed suddenly in equatorial Africa or central Australia. But with regard to the sun the case is very different; for although the progress of science has enabled us to detect the presence of certain familiar substances in the atmosphere of our luminary, it has hitherto only shrouded in deeper mystery than ever the origin of that wonderful outpouring of light and heat which is the sun's most prominent characteristic, and to this very day it has not been finally decided whether this luminosity proceeds from the sun's solid body, or from an envelope which surrounds it. Indeed so strange and so unaccountable are many of the features presented to us, not only by our own sun, but by many of the stars, that it has even been conjectured that these bodies exhibit instances of the operation of some force of the nature of which we are yet ignorant. If we accept this view of the case, the study of our luminary becomes one of very great importance, but one in which we must be very careful to be guided by observation alone. We must obtain numerous and accurate representations of the sun's surface, and study these carefully and minutely, before we attempt to generalize.

§ I. *Methods of observation.*

2. There are two methods of accomplishing this. (1.) Eye-observations of the sun's surface may be made by means of a

* From a memoir printed for private distribution.

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telescope, and the appearance carefully mapped by the observer. (2.) Or we may call to our aid that art which has already proved of signal service in many branches of science, and, by means of photography, obtain autographs of our luminary, which we may measure and examine carefully at our leisure.

Each of these has its advocates, but it is not our design to discuss the comparative merits of the two methods; on the contrary, as each has its own special advantages, we are willing to adopt them both, and to avail ourselves of all those materials which our own observations or the kindness of friends may have put into our hands.

§ II. *Historical sketch.*

3. The most important knowledge which we possess regarding the physical appearance and structure of our luminary is derived from the following sources.

4. *Sun's rotation.*—We are, in the first place, indebted to Galileo, if not for the first discovery of sun-spots, at least for the first attempt to ascertain through their means the period of rotation of our luminary.

5. *Nature of sun-spots.*—The next great advance in solar physics is due to Alexander Wilson, Professor of Astronomy at Glasgow, who in 1773, communicated a paper to the Royal Society, describing certain phenomena with regard to spots, which, in his opinion and in that of many others, appear to indicate that spots are cavities in a luminous photosphere which surrounds the sun.

The accuracy of this conclusion has recently been questioned; but whatever may be said regarding the theory, there can be no doubt regarding the importance of the fact which was first revealed by Wilson.

6. *Their periodicity.*—The next step is due to Hofrath Schwabe, of Dessau, who has shown, as the result of nearly forty years' laborious observations, that the number of spots which break out on the sun's surface is not the same from year to year, but has a maximum about every ten years—a remark which led General Sabine to observe that the various epochs of maximum spot-frequency were also those of maximum magnetic disturbance in our own globe.

7. *Their proper motion, &c.*—Carrington is the next observer who has greatly extended our knowledge of this subject. In a large and most remarkable work recently published, and containing the result of many years' observation, he has shown that sun-spots have a proper motion of their own, those near the solar equator moving faster than those near the poles; and he has also made interesting remarks on the distribution of spots in solar latitude for different years. In addition to these new

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facts, he has furnished us with very accurate data regarding the sun's rotation.

8. *Gradations in their luminosity.*—We ought also to mention the discovery by Dawes, that what is regarded as the umbra of a spot consists in many cases of two well-defined and separate parts,* the exterior part being less luminous than the interior; so that we have often connected with the same phenomenon not less than five degrees of luminosity: these are—(1.) The faculæ. (2.) The ordinary photosphere. (3.) The penumbra. (4.) The borders of the umbra. (5.) The very dark central nucleus.

Mr. Dawes's discoveries are mainly due to his employing, with an eye-piece of his own invention, the full aperture of the telescope; but it is necessary to recall the fact that Sir William Herschel, in earlier times, was fully aware of the importance of not contracting the aperture of the objective. Moreover, we must not forget that Sir W. Herschel contributed to solar physics a theory which still holds its ground.

9. *Red flames.*—But there is another phenomenon connected with our luminary, not less curious than solar spots. We allude to the red flames, or protuberances which are seen to surround the sun's disk on the occasion of a total eclipse. Airy and Arago were the first to conjecture that these belonged to the sun. In the total eclipse of 1851, the former of these observers, by combining his observations with those of O. Struve, showed it to be probable that these flames do not change *during the moon's motion.* Great credit is also due to this observer for organizing the Spanish expedition of 1860; and it was here that Mr. De la Rue, by means of the Kew heliograph, set the matter completely at rest. Mr. De la Rue, from the pictures which he obtained, was able to show that the flames only change apparently, not really, by the moon's motion over them, that is, by covering one portion and disclosing another, and do not otherwise undergo any alteration; so that when the clock of his instrument was adjusted to the sun's motion, that portion of the flames not covered by the moon stood still. He also showed that the angular motion of the red flames, with respect to the moon, corresponds to the theory of their fixation in the sun.

These results were verified by Secchi, who also obtained photographs of the same phenomenon, which were compared in Rome by Mr. De la Rue and Father Secchi with Mr. De la Rue's photographs. The forms of the red prominences were found identical in both, so that no change occurs in their form during an interval much longer than the duration of totality observations in a solar eclipse.

* In some cases, however, it is fair to assume that the appearance of lighter portions of the umbra may be caused by the floating across of portions of the brighter part of the sun's surface.

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10. *Willow-leaves.*—We may be allowed to mention here that very lately Mr. James Nasmyth, during the course of his observations of the sun's surface, has come to the conclusion that, when the circumstances of observation are very favorable, the whole surface will be found to be composed of separate luminous bodies, of a great similarity of figure, interlacing one another; and he has given the name of *willow-leaves* to these appearances. The existence of these is still disputed; but some of our best observers in this country have seen them under very favorable atmospheric conditions, and they have been seen more frequently by Secchi and other Italian observers.

11. *Other observations of the sun's surface.*—Chacornac, the eminent French observer, has noticed a behavior of those portions of the sun's surface around a spot, which seems to imply the existence of a downward current. More recently Lockyer, in this country, has made a very important observation of a similar kind. A tongue of faculous matter projecting over a spot was observed to lose its brilliancy very rapidly, so as ultimately to seem less brilliant than any portion of the penumbra. At the same time it seemed to be "giving out," as it were, at its end, and a portion of the umbra between it and the penumbra appeared to be veiled with a stratus cloud evolved out of it.

We ought likewise to mention the excellent and numerous observations of Pastorff, preserved in the library of the Royal Astronomical Society, also those of Captain Shea, both of which the Council of that Society have placed at our disposal. Professor Wolf, of Zurich, has collected data for establishing the periodicity of sun-spots before the commencement of Schwabe's observations. Also, the Rev. J. Howlett, in this country, has produced a large series of drawings of the sun's surface on a large scale, and of exquisite delicacy of delineation, which will no doubt prove of much value; and, finally, this field of research is one that has been occupied by many observers in all parts of the world, so that we may hope with some confidence for a speedy increase of our knowledge in this very important branch of physical astronomy.

12. *Composition of solar atmosphere.*—Before concluding this very brief historical sketch, we ought to allude to the discovery of Kirchhoff and Bunsen, who, by means of the spectroscope, have proved that many familiar substances, such as sodium, iron, magnesium, &c., exist in the atmosphere of our luminary in the state of vapor.

§ III. *Materials at the author's disposal.*

13. We now proceed to describe what materials we have at our disposal for the purpose of these investigations.

In the first place, Mr. Carrington has very kindly put into

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our hands all his original drawings of sun-spots. These extend from November, 1853, to March, 1861; and in them the sun's disk is represented on the scale of one foot in diameter, while, for each spot, the apparent position on the disk, as well as the proportion in size to the whole surface, is accurately delineated. We hope, in our investigations (as far as spots are concerned), to make much use of these pictures by Carrington; they do not, however, afford us any information with regard to faculæ.

More recently we have received into our hands the magnificent collection of drawings of the sun made by Hofrath Schwabe, of Dessau, during the course of about forty years,—this distinguished observer having generously placed these in the possession of the Royal Astronomical Society, for the use in the meantime of the Kew Observatory.

Our materials are, moreover, derived from the pictures taken by the Kew heliograph. This instrument, with its various adjustments, has already been described by Mr. De la Rue in the Bakerian Lecture for 1862; and it is therefore unnecessary to give a further description of it here. A few pictures were taken by this instrument at the Kew Observatory in the years 1858 and 1859. In July, 1860, it was in Spain, doing service at the total eclipse. In 1861, a few pictures were taken at Kew; while, from February, 1862, to February, 1863, the instrument was in continuous operation at Mr. De la Rue's private observatory at Cranford; and from May, 1863 until the present date, it has been in continuous operation at Kew, under Mr. De la Rue's superintendence. It is right to mention that for the perfection of these pictures much credit is due to the late Mr. Welsh and to Mr. Beckley, under whose immediate supervision the pictures at Kew have been taken by a qualified assistant, Miss Beckley.

§ IV. *Method of reduction.*

14. These are the materials at our disposal; and it may here be desirable to state in a few words the principle by which we shall be guided in our reduction of these materials. In the progress of this branch of knowledge, observers have been led to recognize certain laws, which represent the average behavior of sun-spots; but to each of these laws there are individual exceptions. In this state of things it is probable that our knowledge of the subject will ultimately be advanced, not only by a study of those groups which behave in a normal manner, but also by a study of those which are exceptions in their behavior to the general rule; and on this account it has been thought desirable to publish the results in such a way that any one may be able as far as possible to study the appearance and behavior, in fact, the whole history of any one group. Setting aside, in the meantime, Schwabe's drawings for future consideration, we propose

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to adopt the following plan of publication for Carrington's pictures and for those of the Kew heliograph. In discussing Carrington's observations, we shall of course adhere to the numbering of his different groups, which he has given; and as he has also exhibited a pictorial history of each of these groups in his published volume, in which the spots are represented, though on a smaller scale than in his original drawings, all that is necessary on our part is to accompany any remark we may make regarding one of Carrington's groups with the number of that group as given by him.

Next with regard to the Kew pictures. Beginning with the first picture in 1858, it is our intention to number each group of spots in the same manner as Carrington, calling the first No. 1, and so on upwards to the present date. It is also our intention ultimately to publish carefully copied representations of each of the Kew groups; but these are not yet ready. We think it well, however, to give at once the numbers of the groups, coupled with the dates at which each group was first seen, and also to make use of these numbers in our present paper in anticipation of the forthcoming pictorial representations, which, when they appear, will enable our readers to judge for themselves of the truth of our remarks.

[The table and some comparisons of the Kew observations with those of Schwabe are omitted.]

§ V. *Two classes of investigations.*

18. Our investigations may be divided into two classes:

(1.) Those in which remarks are made regarding the behavior and appearance of spots and faculæ, and generalizations deduced therefrom, which do not involve accurate measurements.

(2.) There are, however, certain results in order to obtain which it is necessary to make use of accurate measurements of the position of spots: such are those from which Carrington has deduced the proper motion of spots on the sun's surface. Probably for this class of observations no better method can be adopted than that so ably pursued by him; but since we have materials at our disposal embracing accurate photographic delineations, we are perhaps called upon to attempt corrections which he has not applied.

19. *Correction for solar atmosphere.*—The most important of these is the correction due to the refraction of the solar atmosphere, which Carrington has indicated, but without applying it, in his large volume. There are evident proofs of the existence of such an atmosphere; for

(1.) In the Kew photographs the central portion of the disk uniformly indicates a greater luminosity than the borders, as if the rays at the borders had to pass through a large extent of

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atmosphere. It is worthy of remark that the temperature of this atmosphere must be lower than that of the photosphere; otherwise the absorption which it occasions would be counterbalanced by its radiation.

(2.) The beautiful discovery of Kirchhoff leads to the same conclusion, since, in order to account for the dark lines of the solar spectrum, it is necessary to suppose the existence of a solar atmosphere of a lower temperature than the source of light.

(3.) The red flames which are visible during a total eclipse, and which have been proved to belong to the sun (Art. 9), indicate the existence of a solar atmosphere extending in some instances as far as 72,000 miles above the photosphere. This is confirmed by the nature of the light which these flames emit. Mr. De la Rue has found that this light is very rich in actinic rays, so much so that he was able to photograph at least one protuberance which was not visible to the eye. Now it is precisely this description of light which characterizes the electric discharge in which gaseous matter appears in a highly heated state.

20. Let us now endeavor to show the nature of those corrections which are rendered necessary by solar refraction.

(1.) A solar atmosphere will make the sun's photosphere to appear larger than it really is; but the angular distance between two points, each near the center of the visible disk, will not be appreciably altered. This will introduce a slight error into the calculated position of any point, since in such a calculation we make use of the sun's apparent angular diameter, which is greater than his true diameter.

(2.) Apart from this, an error will be introduced into the calculation of the solar latitude and longitude of a point, this error depending upon its position in the visible disk, and being greater for those points which are at a distance from the center.

§ VI. *Questions to be answered in the present paper.*

21. In the present paper we shall attempt to answer the following questions:—

(I.) Is the umbra of a spot nearer the sun's center than its penumbra? or, in other words, is it at a lower level?

(II.) Is the photosphere of our luminary to be viewed as composed of heavy solid, or heavy liquid matter? or is it rather of the nature of a cloud? A short explanation will render evident the meaning of this question. There are two types, either of which we may conceive as representing the solar photosphere: we may, in the first place, suppose it to be a solid or liquid plane more or less uneven, with a heavy atmosphere above it. This atmosphere may be composed either of quite different materials from those of the liquid plane, or it may contain some of the materials of the plane in a state of vapor. Our own ocean is

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an example of this type, the air above it being composed chiefly of materials different from those of the ocean, but containing also aqueous vapor. On the other hand, we may imagine the sun's photosphere to resemble a cloud, the characteristic of which is solid or liquid particles of a greater or less size existing in a gaseous atmosphere, composed to a greater or less extent of the materials of the cloud. These points must be determined by observation alone. We must ask if the appearances presented by the sun's photosphere lead to the conclusion that it is an uneven plane of heavy liquid or solid matter, or do they induce us to imagine that it is rather of the nature of a cloud?

(III.) Is a spot, including both umbra and penumbra, a phenomenon which takes place beneath the level of the sun's photosphere or above it?

22. In the first place, therefore, and to answer the first question, let us see what will happen if the umbra of a spot be nearer the sun's center than the penumbra?

If the umbra be lower than the penumbra, when a spot passes over the sun's disk, the umbra will always appear to encroach upon that side of the penumbra which is directed toward the visual center of the sun's disk; and this effect will be lessened through the refraction caused by a solar atmosphere, but we cannot conceive that it will be wholly obliterated. If therefore the umbra is appreciably at a lower level than the penumbra, we are entitled to look for an apparent encroachment of the former upon the latter on that side which is nearest the visual center of the disk. This in fact was the phenomenon which Wilson observed, and which led him to the belief that the umbra was nearer the sun's center than the penumbra.

23. In the following six sub-tables the effect of foreshortening is estimated in the direction from left to right, this being the direction in which spots advance across the visible disk by rotation; and for this purpose the whole surface of the sun has been divided into six portions, comprising 30° each.

[These sub-tables are omitted, the general results from them being given in the following summaries.]

Result of TABLE II_a. *Showing the effect of foreshortening in the direction left and right of the central line.*

a. Giving the mean ratios between the two sides of the penumbra.

Left of central line.					
Within 30° from left limb.		Between 30° and 60° from left limb.		Within 30° from central line.	
No. of spots observed.	The penumbra on the *right* side of a spot being equal to unity, that on the *left* is equal to	No. of spots observed.	The penumbra on the *right* side of a spot being equal to unity, that on the *left* is equal to	No. of spots observed.	The penumbra on the *right* side of a spot being equal to unity, that on the *left* is equal to
130	1·8	119	1·4	88	1·2

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Result of TABLE II_a.—continued.

Right of central line.					
Within 30° from central line.		Between 30° and 60° from right limb.		Within 30° from right limb.	
No. of spots observed.	The penumbra on the *left* side of a spot being equal to unity, that on the *right* is equal to	No. of spots observed.	The penumbra on the *left* side of a spot being equal to unity, that on the *right* is equal to	No. of spots observed.	The penumbra on the *left* side of a spot being equal to unity, that on the *right* is equal to
91	1·2	77	1·3	100	1·6

b. *Giving the percentage of cases, out of* 530 *observations in all, which are in conformity with the assumption, that the umbra is nearer to the center of the sun than the penumbra, and of cases which are against it.*

Left of central line.											
Within 30° from left limb.				Between 30° and 60° from left limb.				Within 30° from central line.			
For.		Against.		For.		Against.		For.		Against.	
No.	Per cent.	No.	Per cent.	No.	Per cent	No.	Per cent.	No.	Per cent.	No.	Per cent.
119	92·3	10	7·7	99	90·0	11	10·0	55	86·1	9	13·9
Right of central line.											
Within 30° from central line.				Between 30° and 60° from right limb.				Within 30° from right limb.			
For.		Against.		For.		Against.		For.		Against.	
No.	Per cent.	No.	Per cent	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Percent.
46	74·2	16	25·8	55	79·7	14	20·3	82	85·4	14	14·6

The whole number of cases observed is 605; excluding herefrom 75, where the penumbra is equal on both sides, there remain 530, of which 456, or 86·04 per cent are *for*, and 74, or 13·96 per cent are *against* the assumption.

Result of TABLE II_b.

Showing the effect of foreshortening in the direction above and below the Equator.

Above the equator.					Below the equator.				
The lower part of the penumbra of each spot being equal to unity, the upper part is equal to	For assumption.		Against assumption.		The upper part of the penumbra of each spot being equal to unity, the lower part is equal to	For assumption.		Against assumption.	
	No. of cases.	Per cent.	No. of cases.	Per cent.		No. of cases.	Per cent.	No. of cases.	Per cent.
1·54	42	87·5	6	12·5	1·33	30	73·2	11	26·8

The whole number of cases considered is 89, of which 72, or 80·9 per cent, are for, and 17, or 19·1 per cent, against the assumption, that the umbra is nearer to the center of the sun than the penumbra.

In table II_b, since the relative disposition of umbra and penumbra is estimated in directions parallel to circles of solar longitude, only spots having a higher solar latitude have been considered.

It will be seen that the results of tables II_a and II_b are decidedly in favor of Wilson's hypothesis.

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24. Let us now endeavor to answer the second question—"Is the photosphere of our luminary to be viewed as composed of heavy liquid or solid matter, or is it of the nature of a cloud?" One characteristic of the sun's surface is the appearance (especially in connexion with spots) of faculæ, or patches of a brightness greater than that of the photosphere immediately around them, this difference in brightness being much more conspicuous near the limb than near the center. One explanation of these phenomena would be, that the luminous matter of the sun has been thrown up to a great elevation in order to form faculæ. This would account for the greater comparative luminosity of faculæ near the border. For we have already mentioned (Art. 19) that the absorbing effect of the solar atmosphere is very perceptible near the border, where the light reaching us has to travel through a greater thickness of atmosphere; and hence, if the luminous matter be thrown up to a great elevation, it will, near the border, escape a great portion of this atmosphere, and will therefore appear relatively much brighter than the surface around it. On the other hand, very little will be gained when the matter is thrown up near the visual center, where we may imagine the atmospheric absorption to be comparatively small. The idea that faculæ are portions of the photosphere raised above the general surface, appears to be confirmed by stereoscopic pictures of spots obtained by Mr. De la Rue, where the faculæ appear as elevated ridges surrounding the spots. Accepting this conclusion, we next remark that faculæ often retain the same appearance for several days together, as if their matter were capable of remaining suspended for some time.

Now if we suppose that such faculæ represent the ordinary luminous matter of the sun, the facts above recorded would appear to throw much light upon the nature of the solar surface, since we cannot imagine faculæ to be the most elevated positions of a liquid ocean, which has been pushed high up into the solar atmosphere, or to be portions of matter projected from such an ocean. Such an hypothesis would appear to be inconsistent with the fact that the faculæ retain their appearance unchanged for days together. At any rate we venture to think that such an hypothesis would not readily be received, and that, according to the rules which ought to guide our judgment in a case like the present, it ought to be set aside if we can find a more plausible explanation. Such an explanation would appear to consist in supposing that faculæ, and, indeed, the whole photosphere of our luminary, are more of the nature of a cloud. A cloud has been defined by Sir J. Herschel to consist of solid or liquid matter, formed from the condensation of a vapor not *floating* in æquilibrio, but sinking in a gaseous medium of less specific gravity than itself—sinking, however, with extreme slowness,

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owing to the minuteness of its particles, and consequent (relatively) enormous resistance of the air. This illustrious savant is disposed to think that the consideration of Cagniard de Latour's experiments on the vaporization of liquids under high pressure would incline us to regard the solar faculæ as large aggregations of *bonâ fide solid matter* of a high degree of fixity, and in masses like gigantic soot-flakes of any form and magnitude, which, when formed, settle down to such a level as corresponds to their density when they rest *in æquilibrio* in a gaseous fluid of their own specific gravity. We do not wish either to accept or to reject this hypothesis, but would frame the following statement, which also includes this view of the case: *Solar faculæ consist of solid or liquid bodies of a greater or less magnitude, either slowly sinking or suspended in æquilibrio in a gaseous medium.*

25. In connection with this part of our subject it will be well to investigate the relative position of spots and their accompanying faculæ; and this is done in the following table for all the Kew pictures available for this purpose.

[Table III is omitted.]

Result of Table III.

Facula entirely or mostly *left* of spot.		Facula entirely or mostly *right* of spot.		Facula *all round* or between the spots.	
No. of cases.	Per cent of the whole.	No. of cases.	Per cent of the whole.	No. of cases.	Per cent of the whole.
584	51·4	45	4·0	508	44·6

26. It appears from the result of table III, that out of 1137 cases 584 have their faculæ either entirely or mostly on the left, while 508 have it nearly equally on both sides, and only 45 mostly on the right. Hence we see that faculæ are on an average to the left of their accompanying spots. The most obvious explanation of this would be that the faculæ of a spot have been uplifted from the very area occupied by that spot, and have fallen behind to the left from being thrown up into a region of greater velocity of rotation. All this is quite in accordance with our hypothesis regarding the nature of faculæ. We would likewise here remind our readers that we know from the observations of Kirchhoff that the sun's atmosphere contains vapors of substances, such as iron, which are condensed into the liquid or solid state at a comparatively high temperature. Now is it not natural to suppose that in the sun's photosphere we do really see such vapors so condensed, and very unnatural to imagine that such vapors are seldom or never condensed, and that what we really see is an incandescent plain underlying these vapors?

27. Let us now attempt to answer the third question: Is a

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spot including both umbra and penumbra a phenomenon which takes place beneath the level of the sun's photosphere or above it? To decide this question, let us state that there are a good many instances in which a spot breaks up in the following manner. A bridge of luminous matter of the same apparent luminosity as the surrounding photosphere, and unaccompanied by any penumbra, appears to cross over the umbra or center of a spot. There is good reason to think that this bridge is really above the spot; for were the umbra an opaque cloud, and the penumbra a semiopaque cloud, both being above the sun's photosphere, it is unlikely that the spot would break up in such a manner that the terrestrial observer should not perceive some penumbra accompanying the luminosity. Again, detached portions of luminous matter appear to move across a spot without producing any permanent alteration. We are on these accounts disposed to think that a spot including both umbra and penumbra is a phenomenon which takes place beneath the level of the brighter part of the sun's photosphere.

28. Let us here recapitulate the answers we have given to our three questions.

(1.) The umbra of a spot is nearer the sun's center than its penumbra, or, in other words, it is at a lower level.

(2.) Solar faculæ, and probably also the whole photosphere, consist of solid or liquid bodies of greater or less magnitude, either slowly sinking or suspended *in æquilibrio* in a gaseous medium.

(3.) A spot including both umbra and penumbra is a phenomenon which takes place beneath the level of the sun's photosphere.

§ VII. *Concluding remarks.*

29. It would thus appear that the central part of a spot is nearer the sun's center than the penumbra, and that both the umbra and penumbra are probably beneath the general level of the surrounding photosphere. Now the umbra or lowest part of a spot is much less luminous than the general photosphere. But what does this probably imply, according to the laws with which we are acquainted? It implies that in a spot there is probably some matter of a lower temperature than the photosphere. For is it not now recognized as a law, that if a substance, or combination of substances, of indefinite thickness and surface of small reflecting power have all its particles at a certain fixed temperature, this substance will give out nearly all the rays of heat belonging to that temperature? Now the sun, even when we look into a spot, is certainly a substance of indefinite thickness; and since a spot appears much less luminous than the ordinary surface, ought we not to conclude either that we there view matter of a lower temperature than the ordinary

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surface, or that the matter which appears within a spot has a very high reflecting power compared to the ordinary matter of the photosphere? This last supposition is an unlikely one, and the probability is that in a spot we view matter of a lower temperature than the photosphere.

30. Presuming this to be the case, it appears to imply one of three things.

(1.) Either the general body of the sun at the level of the bottom of a spot is of a lower temperature than the photosphere;

(2.) Or the lower temperature is produced by some chemical or molecular process which takes place when a spot is formed;

(3.) Or it is produced by matter coming from a colder region.

The first of these suppositions will not be generally received unless we are fairly driven to accept it.

The second hypothesis has already been started to account for the lower temperature of a spot; but we think that, according to the laws by which we should be guided in receiving or rejecting an explanation in a case of this nature, this idea ought to be rejected.

No doubt, if we knew of a case of the production of low temperature, and had at the same time an independent proof of some chemical or molecular process, such as evaporation, it would be quite allowable for us to associate the chemical or molecular process with the production of cold as at any rate the most likely hypothesis; but we do not advance in our explanation of the low temperature by attributing it to an imaginary process of the existence of which we have no proof, and which is equally mysterious with the phenomenon for which it is supposed to account. Rather let us see if this reduction of temperature can be explained by any other phenomenon of the existence of which we have independent evidence. This leads us to consider the third hypothesis, which supposes that the reduction is produced by matter coming from a colder region. Now, in the first place, we have such a region in the atmosphere above the photosphere, which (Art. 19) we have shown to be of a lower temperature than the photosphere itself. Again, the observations of Chacornac and Lockyer on the behavior of the matter surrounding a spot appear to suggest the existence of a downward current, which is therefore a current from the colder regions above.* On the other hand, the proper motion of spots observed by Carrington is in favor of this hypothesis, since a current coming from a region of greater to a region of less absolute velocity of rotation would be carried on forward, and most so nearest the equator; and this is precisely the motion of

* Does not the observation by Lockyer of the facula "giving out" appear also to indicate that the lower regions of a spot are in reality hotter than the surface, leaving the inferior luminosity to be accounted for by the downrush of a cold atmosphere from above?

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spots observed by Carrington. Again, we have seen (Art. 26) that the faculæ fall behind; so that we may imagine two currents to be engaged in the formation of a spot,—the one an ascending current carrying the hot matter behind, the other a descending current carrying the cold matter forward. One advantage of this explanation is that all the gradations of darkness, from the faculæ to the central umbra, are thus supposed to be due to the same cause—namely, the presence to a greater or less extent of a comparatively cold absorbing atmosphere.

31. It is but just to ourselves and to M. Faye, to mention that both have imagined the phenomenon of sun-spots to be due to ascending and descending currents. M. Faye's hypothesis was published a little before ours; but we shall readily be believed when we state that an idea of this kind presided over the construction of table III, in which we have proved that the faculæ are, on an average, to the left of their accompanying spots. It was not, however, until a short time before the publication of the abstract of this paper by the Royal Society, that, by discussing the subject together, we had matured our views so far as to connect the descending current, not only with Carrington's proper motion, but also with the presumed lower temperature of a spot. In this last respect our hypothesis differs entirely from that of M. Faye, who does not imagine that the inferior luminosity of a spot indicates the presence of matter at a lower temperature than the photosphere.

32. In conclusion, we would venture to suggest that if the photosphere of the sun be the plane of condensation of gaseous matter, this plane may be found to be subject to periodical elevations and depressions in the solar atmosphere. It may be that at the epoch of minimum spot-frequency this plane is uplifted very high in the solar atmosphere, so that there is comparatively little cold absorbing atmosphere above it, and therefore great difficulty in forming a spot. If this were the case we might expect a *less* atmospheric effect or gradation of luminosity from the center to the circumference at the epoch of minimum than that of maximum spot-frequency. Perhaps on some future occasion we may be able to produce evidence of this, and even of the unequal atmospheric effect of the two limbs of the sun at the same time; but in the meantime we shall content ourselves with suggesting this to the observers of our luminary as a simple inquiry that may possibly prove productive.

33. We are especially desirous of bringing under the early notice of the scientific world the accumulation of observations we are making, in order that others may put forth their own conjectures in elucidation of solar physics. In venturing the opinions we have stated, we do so with some reserve, and with the conviction that possibly they may hereafter require modifications.

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ART. XX.—*On the Subterranean Sources of the Waters of the Great Lakes;* by GEORGE A. SHUFELDT.

IF we take down the map of North America, and follow around the borders of our chain of Great Lakes, we find that the tributaries for supplying the mighty torrent of water which pours in immense volumes over the Falls at Niagara, and thence through the St. Lawrence to the sea, are few in number and insignificant in effect. Lake Superior, the largest body of fresh water in the world, has an area of 32,000 square miles and a mean depth of one thousand feet. There are a few small streams, none worthy of the name of rivers, which find their outlet in this lake—the St. Louis and Ontonagon are the largest of these; but there is probably not water enough discharged into the lake to make up for the atmospheric absorption and evaporation. The entire State of Wisconsin, even from the very borders of Lake Superior, is drained by rivers, which flow into, and are tributaries of the Mississippi. These are, in chief, the Wisconsin River, the Black, Chippewa, Fox and Rock Rivers, the waters of which all flow southward, to the Gulf of Mexico. The whole State of Minnesota with its thousands of lakes and streams may be called the mother of the Father of Waters—for all of her waters which do not gather into the great Red River of the North are discharged into the Mississippi, and do not contribute to keep up the supply of Lake Superior; and on the northern shore of the lake, in the British possessions, there are no rivers which flow in this direction. Here the current is the other way and the streame find their way to Hudson's Bay and other more northerly seas. The outlet of Lake Superior is the River St. Mary's—a stream of considerable magnitude—which discharges the surplus waters of the Lake in the direction of Lake Huron. Lake Superior is 627 feet above the sea level.

If we examine the surroundings of Lake Michigan we shall find the evidences of this theory still more striking. This lake has an area of 22,400 square miles, and a mean depth of 900 feet. It is above the sea level 578 feet or forty-nine feet below Lake Superior. It is also an immense body of water, whose sole apparent sources of supply are found in a few small streams which flow into it from the State of Michigan.

The largest of these are the Grand and Manistee rivers; from Wisconsin there is only one small stream, the Milwaukee river at Milwaukee. From Illinois there is only the Chicago river, a sluggish stream without a current; and indeed there is, at only ten miles distance from the banks of the lake south and west,

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the water-shed called the Summit, which separates the waters which flow into the St. Lawrence from those which flow into the Gulf of Mexico, and from the southern slope of this Summit, flowing southward, is the Aux Plaines river, a tributary of the Illinois. So that Lake Michigan gets no water from Illinois, but a trifle from Wisconsin, and very little from Michigan. And yet the straits of Mackinaw carry off a large quantity of water from this lake, and Lake Michigan furnishes its due proportion of the great current which passes over the Falls of Niagara. Now the question arises, whence comes this great volume and mass of running water?

Geologists are tolerably familiar with the subject of underground streams and water courses. They know that the crust of the earth is full of these streams, and although from the fact that they are generally concealed from sight, there must be considerable speculation concerning them, yet there are cases, such as in the Mammoth Cave, Kentucky, the Adelsberg mountains in Switzerland, and numerous artesian wells scattered all over the world, the lost rivers on our western prairies, &c., from which a positive knowledge may be derived concerning the nature and history of these rock-bound rivers.

The artesian wells in London furnish now about 12,000,000 of gallons of water daily. This is the seepage of the valley in which the great city is located. The water from the whole country surrounding finds its way along the tilts and inclinations of the broken strata, below the chalk beds, in among the sands and gravel, whence it is taken by boring into the ground to the depth of about 600 feet. It does not appear probable that there are any considerable streams in this vicinity, for the entire of the underlying gravel beds seem, as it were, saturated with water, which is reached at any point of perforation.

These remarks apply to the wells of Grenelle and of Passy, in the basin of Paris, with the exception in the case of the latter that they struck an amazing stream of water eighteen hundred feet below the surface which discharges nearly six millions of gallons per day, rushing to the surface with great power and velocity. This is strong evidence, certainly, of a great underground stream at this point. The great wells of Kissingen in Bavaria, at Munden in Hanover, at Louisville in Kentucky, Charleston, S. C., and hundreds of others, many of which are two thousand feet deep, discharging great volumes of water—all tend to demonstrate the fact that the crust of the earth is penetrated in all directions and at all depths with these streams and water courses.

Adopting this as a conceded fact, let us once more turn to the map of North America and note particularly the point where the thirty-second degree of west longitude crosses the forty-fourth parallel of north latitude. Within a radius of five hundred

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miles, of which this is the center, will be found the great water producing region of the West. In this elevated and comparatively uneven surface of the country, nearly all of the great rivers of the West have their sources and fountain-heads. First the Missouri, with its innumerable branches and tributaries, among which are the Yellowstone and the North Fork of the Platte, the Arkansas, the Red River, the Rio Grande, all flowing from the eastern and southern slopes of the Rocky Mountains and finding their way through thousands of miles of country to the Gulf of Mexico. On the western slope is the Rio Colorado, which empties into the Gulf of California, and which is formed by the union of the Grand and Green rivers, the sources of which are also within the territory above mentioned. The same statement is true of the Columbia river flowing through the State of Oregon into the Pacific, and of the other great streams and rivers which flow northward and westward into the Pacific and the Northern oceans. Thus the knowledge we already possess of the surface streams of this great extent of territory all tends to demonstrate the truth of the theory in relation to the water producing region, its location, extent and capacity, and also that on the surface there is but comparatively a small amount of this water which finds its way into our Great Lakes.

It is a well-known fact to travellers on our western plains, that large streams, often rivers in size, suddenly disappear, falling away into great fissures and chasms, sometimes reappearing, but more frequently lost forever; where and in what manner does this water find an outlet? What becomes of the mass of water which falls upon the earth and is absorbed by the soil and the rocks below the beds of rivers and streams? The crust of the earth abounds in water to unknown depths, and from the nature of the element, it must create for itself ways and courses of travel, as plainly beneath as upon the surface. And now, if the Great Lakes are not supplied by means which are upon the the surface and apparent to the eye, it follows as a natural consequence that their sources of supply must be underneath the ground. The outlet of these lakes discharges an enormous quantity of water, the visible inlets are mere trifles in comparison—and thus there seems to be no other conclusion on the subject but that the water supply comes from below the surface of the ground. This water probably finds inlets at different points on the bottoms of the lakes, and maintains the supply with as much certainty and regularity as if the streams were running on the surface of the ground. This theory is further, and I think more particularly demonstrated by the great mass and volume of water which is now being discharged by the Chicago artesian wells. These are over seven hundred feet deep—nearly penetrating the earth to a line parallel with the bottom of Lake Michigan—are located in

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no great valley or depression, such as the basins of Paris or London. The water has a head of nearly one hundred and twenty-five feet above the level of the lake; is much colder than the mean temperature of the location of the wells, being now 57 degrees Fahrenheit; these facts tending to show that it must come from a more elevated region of country, and also from a higher latitude. There are two other facts corroborative of this point. When the water was first struck the temperature was 59 degrees Fahrenheit; it has fallen now two degrees, or to 57. Then, the first analysis of the water exhibited 72 grains to the wine gallon of mineral matter held in solution; the second analysis, made only one year afterwards, showed only 56 grains of the same matter. These facts, taken in connection with the great head of the water, seem to establish exclusively that it comes from some remote region of the north or northwest.

It is also probable that the great under-ground stream, penetrated by these wells, once discharged its waters into the bottom of Lake Michigan; but this outlet was closed by the upheaval of the earth's crust, which is visible at the point of the location of these wells, and at the present time there is no outlet except the artificial one made by the drill. This supposition is proved by the head and the great force and power of the water, for if it had a lower outlet, anything like the size of the stream, it would not show a head much, if any, above the surface of the ground, and it is also sustained by the facts mentioned above—the decrease of the temperature of the water from fifty-nine degrees to fifty-seven degrees, and the diminution in quantity of mineral matter held in solution—the latter fact seeming clearly to prove that prior to the time when the drills penetrated the stream, the water had dissolved and absorbed a large quantity of the soluble matter of the rocks with which it came in contact in its state of rest. As soon as an opening or outlet was made, and a quantity of water was discharged, this mineral matter decreased in proportion, and the probability now is that the water will become softer and purer as the amount discharged becomes greater, and that eventually, and probably at no distant day, the water will come from its fountain-head, simply filtered and purified by its passage through the sandstone and gravel beds.

That the outlet of this stream into Lake Michigan was closed by the upheaval of the earth's crust, is a probable conclusion, which can be verified by an inspection of the grounds on which these wells are located. The surface here is only some seven or eight feet above the level of the surrounding prairie; but geologically or stratigraphically, it is nearly one hundred and fifty feet above the common level of Chicago, that is, at about one mile distant eastward and into the city. We bore

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into the soil nearly one hundred and fifty feet before reaching the same rock, which is here exposed upon the surface, and at the well bored at the Chicago Distillery Company's premises on the North Branch, they penetrated the Joliet marble at a depth, I believe, of one hundred and eighty-six feet, which, at the other point is only twenty-nine feet from the surface; this and various other facts show the nature and extent of this convulsion, and that it was no difficult feat of nature to dam up this comparatively trifling underground stream, and leave its waters pent up in the rocks and caverns for the future use and benefit of man.

I do not know that these speculations will be of sufficient interest to be made public, but they may have the effect of directing some abler pen to the solution of the problem as to the sources whence the Great Lakes derive their supply of water.

Chicago, November, 1866.

ART. XXI.—*Experiments on the Influence of various Organic and Inorganic Bodies upon Germination and Vegetation;* by M. CAREY LEA, Philadelphia.

THE following experiments were made to determine how far the germination of seeds, and subsequent vegetation of the plants, would be controlled or influenced by the action of acid, alkaline and neutral bodies in solution in the water with which the seeds were moistened. It will be seen that the action of the strongest of our acids is insufficient to prevent germination when sufficiently dilute. And that the same may be said with respect to some of our most powerful oxydizing and reducing agents.

The experiments were made by tying pieces of very thin muslin over glass vessels filled so full that the muslin dipped into the liquid. Grains of wheat were placed on this muslin, an equal number (20 perfect grains) on each. The capacity of the glasses was in every case 12½ ounces, and the water was replaced as fast as it evaporated. There was added respectively to each as follows:

No. 1. 1 drop sulphuric acid.
2. 2 drops nitric acid.
3. 3 " hydrochloric acid.
4. 5 grs. bicarbonate of potash.
5. 5 " dry carbonate of soda.
6. 10 drops of rather weak liquid ammonia.
7. 5 grs. bromid of ammonium.
8. A pair of zinc and copper plates connected above the surface by a wire, and plunged in plain water.

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No. 9. Same, acidulated 3 drops hydrochloric acid.
10. Plain water for comparison.
11. 5 grains sulphite of soda.
12. " " chlorate of potassa.

The results were as follows. At the end of

48 *hours*—Germination evident in all. Most advanced, 4, 10, 11; medium, 2; least, 1, 3, 5, 6, 7, 8, 9, 12.

3 *days*—Most advanced, 4, 10, 11; medium, 5, 7, 8, 9, 12; least, 1, 2, 3, 6.

4 *days*—Most advanced, 4, 10, 11; medium, 5, 7, 12; less, 2, 6, 8, 9; least, 1, 3.

5 *days*—Most advanced, 4, 10, 11; medium, 5, 6, 7, 8, 12; less, 1, 9; least, 2, 3.

6 *days*—Most advanced, 4, 10, 11; a little less, 5, 6, 7, 8; much behind, 1, 2, 3, 9.

Some curious deductions are to be drawn from these results. *Nitric acid* did not at first very strongly affect the growth, less than seven other substances, then eventually its influence became much more felt.

Bicarbonate of potash was the least injurious of all the substances tried, next came *sulphite of soda,* and next *carbonate of soda.*

No saline or other substance included acted in any way as a stimulant, the product of the plain water as an average was fully up to any of the rest, though as will hereafter be seen, the largest plant was formed in another vessel.

In the observations just made I have endeavored to show the daily course of action; in the following table I have summed up the total effects at the end of seven days, when experiment was discontinued.

Total results at the end of seven days.

	Proportion of substance in 100 of water.	No. of seeds that germinated out of 20.	Average height of young plants.	Total amount of vegetation.	Proportional amount of vegetation, taking that in plain water as 100.
1.	SO_3, 0·016,	18	·3	5·4	16·8
2.	NO_5, 0·033,	14	·2	2·8	8·7
3.	HCl, 0·050,	8	·3	·9	2·8
4.	$KO\ 2CO_2$, 0·083,	16	2·	32·	100·
5.	$NaO\ CO_2$, 0·083,	14	1·5	21·	65·6
6.	Ammonia,	13	1·5	19·5	60·9
7.	NH_4Br, 0·083,	11	1·4	15·4	48·1
8.	Zn and Cu plates,	16	1·3	20·8	65·0
9.	Same with 3 drops HCl.	8	·4	3·2	10·
10.	Plain water,	16	2·	32·	100·
11.	$NaO\ SO_2$, 0·083,	12	2·	24·	75·
12.	$KO\ ClO_5$, 0·083,	13	·5	6·5	20·3

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This table shows:

That an oxydizing agent, chlorate of potash (12), is not more injurious than a reducing one, sulphite of soda (11), to germination, but after germination it kept down vegetation to one-fourth.

That free acids are much more injurious than alkalies, especially hydrochloric acid (3).

That the presence of an electric pair did not check germination, but reduced vegetation by one-third.

That the presence of free sulphuric acid had no injurious influence upon germination, actually a larger proportion of seeds started than with pure water, whereas with hydrochloric acid only three seeds germinated out of twenty. But sulphuric acid reduced vegetation to one-sixth, hydrochloric to 2·8 per cent.

With bicarbonate of potash, precisely the same number germinated as with plain water, and attained precisely the same height.

In (9) the HCl acted less energetically than in (3), doubtless because it was rapidly taken up by the zinc.

Plants in the sulphite of soda attained the same height as those in plain water. But the number germinating was one-fourth less.

A second set of trials was made, in which a number of other substances were experimented upon, and at the same time sulphuric acid was added in much smaller quantity, and sulphite of soda in much larger. Capacity of the vessel as before, 12½ oz.

No. 1, Plain water.
2, Cane sugar, 30 grains.
3, Gum, 30 grains.
4, Glycerine, 1 fluid drachm.
5, Sulphuric acid, ¼ drop.
No. 6, Citric acid, 5 grains.
7, Sulphite of soda, 20 grains.
8, Permanganate of potash, 2 grains.
9, Nitrate of ammonia, 20 grs.

The object of this series was to include in the experiments certain organic substances such as the three first on the list, a vegetable acid, and some salts whose influence might be active and characteristic.

At the end of thirteen days, during which the weather was very cold (Dec. 10 to Dec. 23), the following was the condition of affairs.

Nos. 2 and 4 (cane sugar and glycerine) were as far advanced as the plain water (No. 1), but no further. These substances therefore had not stimulated either germination or early vegetation in the wheat seeds.

In 3 (gum solution) fewer seeds germinated than in either of the foregoing, but the most advanced plants were *fully one-half higher* than any in 1, 2, or 4.

Nos. 7 and 9 (sulphite of soda and nitrate of ammonia) were somewhat in advance of those in plain water, but not very much.

In 6 (citric acid) a large number germinated, and appeared

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healthy, but they did not obtain one-fourth the height of those in No. 1, and what was very remarkable, they *formed no roots at all.*

In 5 (sulphuric acid) the plants were more advanced than in the citric acid, and had healthy roots extending down into the liquid.

In 8 (permanganate of potash) the condition of affairs most resembled that in the citric acid. In both the seeds had germinated and produced healthy looking plants an inch in height. But *no roots whatever* had been formed in either case.

Some of the above sets of seeds were allowed to vegetate for a month, and developed curious results.

Those plants which grew in the vessels containing solutions of cane sugar, gum, and glycerine respectively, grew as fast and flourished as well as those in plain water, but it could scarcely be said that at the end of the month they presented any superiority.

But whilst the roots of the plants in plain water, in gum, and in glycerine, reached to the very bottom of the vessel, becoming four to five inches long, those in the cane sugar did not exceed an inch in length, just dropping below the surface of the water, which had become lowered by spontaneous evaporation, and this although the plants were as high as in the others just mentioned, viz., six to eight inches, and as numerous and healthy in every respect. This would seem to indicate that they received their nutriment in a more concentrated form, if it were not that these plants, though equally large and healthy as those in plain water, exhibited no superiority over them.

ART. XXII.—*Contributions from the Sheffield Laboratory of Yale College.*—XIII. *On Native Crystallized Terpin;* by S. W. JOHNSON.

IN October, 1866, the writer received from Wm. M. Gabb, Esq., of the Geological Survey of California, a small quantity of crystals found in "cavities near the core of a semi-decomposed pine stump that was buried three or four feet below the surface in Shasta Co., California." The crystals were discovered by Mr. Voy of San Francisco.

At the request of Mr. Gabb I have examined these crystals, which, in the sample received, were still partly adhering to a fragment of pine, where they were associated with another crystalline substance of a yellowish color and resinous aspect.

The crystals were colorless and transparent, the largest individual was three-eighths of an inch long, one-eighth of an inch wide and one-sixteenth of an inch thick. They were of brilliant luster and well terminated at the free ends. From their occurring in buried pine wood and from their general appearance, it

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was at once suspected they might be identical with crystallized terpin. Their faint resinous taste and odor, not to be distinguished from that of the artificial substance, confirmed this view.

To obtain full information regarding the crystallometrical characters of the substance, I applied to my friend, Mr. John M. Blake of New Haven, to make a comparison between the native crystals and those of artificial preparation from the chemical cabinet of the Sheffield Scientific School. Some of the highly interesting results of these investigations are communicated by Mr. Blake in the paper that follows, and leave no doubt of the identity of the two substances, although their crystals are not developed in the same manner, and exhibit other physical differences which, as he states, disappear when both are recrystallized from the same solvent.*

After Mr. Blake had finished his examinations, a combustion was made on nearly the whole available substance. The hydrogen determination was lost by the fracture of the CaCl tube, but the estimation of carbon fully confirmed the conclusions previously arrived at. The combustion was effected in a tube partly filled with oxyd of copper and in a stream of oxygen, the substance itself being placed in a tray of platinum. On application of heat it swelled and afterwards vaporized completely, without blackening and without leaving a weighable residue. On the cold parts of the tube silky crystals of anhydrous terpin condensed. This deportment is characteristic of terpin.

The amount of substance burned was but 0·0975 grm. The increase in weight of the potash bulbs and tube was 0·225 grm. This gives carbon 62·93 *per cent.* The calculated quantity is 63·16 *per cent.*

The substance is therefore hydrated terpin or crystallized turpentine camphor $C_{20}H_{20}O_4+2aq$. Perhaps we should say it is one of the terpins, since, according to Berthelot, the different oils of turpentine, on hydration, yield crystals of different degrees of solubility.

The formation of this substance in the buried tree presents no difficulties, since we know on the authority of Dumas, Deville and others, that oil of turpentine in contact with water, combines with the latter in absence of acids or other powerful agents of chemical change.

Prof. Brewer, who is familiar with the timber of California, is of the opinion that the wood to which the crystals were attached is that of a pitch pine, *Pinus ponderosa.*

This appears to be the first recorded instance of the occurrence of crystallized terpin, native.

November, 1866.

* Mr. Blake has measured and figured both the native and artificial crystals and has in reserve some other valuable observations which it is to be hoped he will shortly publish.—S. W. J.

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ART. XXIII.—*On the crystallization of natural Hydrated Terpin from California;* by JOHN M. BLAKE.

SOME crystals, from a buried pitch-pine log, were handed me for examination by Prof. S. W. Johnson, of the Sheffield Scientific School.

A comparison of these crystals with terpin of artificial preparation leaves no doubt that the natural substance is hydrated turpentine camphor. The natural and artificial crystals agree closely in their angles, and have the same cleavage. The position and separation of the optical axes is alike in both, and experiment shows that the two substances are supercrystallizable.

Certain observations made at first, suggested that the two specimens might not be absolutely identical, but rather isomeric hydrates, such as were supposed by Berthelot to result from isomeric oils, derived from the same or different trees. Thus, hemihedrism constantly occurred on the natural crystals, which has not been observed on the artificial. The proportional development of the planes was strikingly different. The two specimens manifested opposite pyro-electric characters, in so far that the *free-growing* extremities of the natural crystals were antilogue poles, (developed negative electricity on heating,) while those of the artificial crystals, first examined, were the reverse, or analogue poles.

On further investigation, these points of difference disappeared. By recrystallizing from alcohol and other solvents, much variation was produced in the planes. The peculiar development of the natural crystals was not indeed reproduced on the artificial, but the attachment of the latter to the support by the analogue pole, as with the natural crystals, was obtained. On recrystallizing from alcohol, natural terpin lost its hemihedral character, and in case of crystals grown radiating from a support, presented the analogue pole to the solution, like the artificial substance when deposited from the same solvent. Crystals of each, when free-growing in alcoholic solution, had the same development of the planes, and with each there was the same perceptible difference in the proportions of the planes at the two ends of a crystal, by which the poles could be distinguished; but no corresponding difference could be detected in the angles of these terminal planes.

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ART. XXIV.—*On the Objects and Method of Mineralogy;* by T. STERRY HUNT, F.R.S.

(Read before the American Academy of Sciences, Jan. 8, 1867).

MINERALOGY, as popularly understood, holds an anomalous position among the natural sciences, and is by many regarded as having no claims to be regarded as a distinct science, but as constituting a branch of chemistry. This secondary place is disputed by some mineralogists, who have endeavored to base a natural-history classification upon such characters as the crystalline form, hardness, and specific gravity of minerals. In systems of this kind, however, like those of Mohs and his followers, only such species as occur ready formed in nature are comprehended, and the great number of artificial species, often closely related to native minerals, are excluded. It may moreover be said in objection to these naturalists, that, in its wider sense, the chemical history of bodies takes into consideration all those characters upon which the so-called natural systems of classification are based. In order to understand clearly the question before us, we must first consider what are the real objects, and what the provinces, respectively, of mineralogy, and of chemistry.

Of the three great divisions, or kingdoms of nature, the classification of the vegetable gives rise to systematic botany, that of the animal to zoology, and that of the mineral to mineralogy, which has for its subject the natural history of all the forms of unorganized matter. The relations of these to gravity, cohesion, light, electricity, and magnetism, belong to the domain of physics; while chemistry treats of their relations to each other, and of their transformations under the influences of heat, light, and electricity. Chemistry is thus to mineralogy what biology is to organography; and the abstract sciences, physics and chemistry, must precede, and form the basis of the concrete science, mineralogy. Many species are chiefly distinguished by their chemical activities, and hence chemical characters must be greatly depended upon in mineralogical classification.

Chemical change implies disorganization, and all so-called chemical species are inorganic, that is to say unorganized, and hence really belong to the mineral kingdom. In this extended sense, mineralogy takes in not only the few metals, oxyds, sulphids, silicates, and other salts, which are found in nature, but also all those which are the products of the chemist's skill. It embraces not only the few native resins and hydrocarbons, but all the bodies of the carbon series made known by the researches of modern chemistry.

The primary object of a natural classification, it must be re-

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membered, is not like that of an artificial system, to serve the purpose of determining species, or the convenience of the student, but so to arrange bodies in genera, orders, and species as to satisfy most thoroughly natural affinities. Such a classification in mineralogy will be based upon a consideration of all the physical and chemical relations of bodies, and will enable us to see that the various properties of a species are not so many arbitrary signs, but the necessary results of its constitution. It will give for the mineral kingdom what the labors of great naturalists have already nearly attained for the vegetable and animal kingdoms.

Oken saw the necessity of thus enlarging the bounds of mineralogy, and in his Physiophilosophy, attempted a mineralogical classification; but it is based on fanciful and false analogies, with but little reference either to physical or chemical characters, and in the present state of our knowledge is valueless, except as an effort in the right direction, and an attempt to give to mineralogy a natural system. With similar views as to the scope of the science, and with far higher and juster conceptions of its method, Stallo, in his Philosophy of Nature, has touched the questions before us, and has attempted to show the significance of the relations of the metals to cohesion, gravity, light, and electricity, but has gone no farther.

In approaching this great problem of classification, we have to examine—first, the physical condition and relations of each species, considered with relation to gravity, cohesion, light, electricity, and magnetism; secondly, the chemical history of the species; in which are to be considered its nature, as elemental or compound, its chemical relations to other species, and these relations as modified by physical conditions and forces. The quantitative relation of one mineral (chemical) species to another, is its equivalent weight, and the chemical species, until it attains to individuality in the crystal, is essentially quantitative.

It is from all the above data, which would include the whole physical and chemical history of inorganic bodies, that a natural system of mineralogical classification is to be built up. Their application may be illustrated by a few points drawn from the history of certain natural families.

The variable relations to space of the empirical equivalents of non-gaseous species, or in other words, the varying equivalent volume, (obtained by dividing their empirical equivalent weights by the specific gravity,) shows that there exist in different species very unlike degrees of condensation. At the same time we are led to the conclusion that the molecular constitution of gems, spars, and ores, is such that those bodies must be represented by formulas not less complex, and with equivalent weights far more

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elevated than those usually assigned to the polycyanids, the alkaloids, and the proximate principles of plants. To similar conclusions, conduce also the researches on the specific heat of compounds.

There probably exists between the true equivalent weights of non-gaseous species, and their densities, a relation as simple as that between the equivalent weights of gaseous species and their specific gravities. The gas, or vapor of a volatile body constitutes a species distinct from the same body in its liquid or solid state; the chemical formula of the latter being some multiple of the first, and the liquid and solid species themselves, often constituting two distinct species, of different equivalent weights. In the case of analogous volatile compounds, as the hydrocarbons and their derivatives, the equivalent weights of the liquid or solid species approximate to a constant quantity, so that the densities of those species, in the case of homologous or related alcohols, acids, ethers and glycerids, are subject to no great variation. These non-gaseous species are generated by the chemical union, or identification, of a number of volumes or equivalents of the gaseous species, which varies inversely with the density of these species. It follows from this, that the equivalent weights of the liquid and solid alcohols and fats must be so high as to be a common measure of the vapor-equivalents of all the bodies belonging to these series. The empirical formula, $C_{114}H_{110}C_{12}$, which is the lowest one representing the tristearic glycerid, ordinary stearine, is probably far from representing the true equivalent weight of this fat in its liquid or solid state; and if it should hereafter be found that its density corresponds to six times the above formula, it would follow that liquid acetic acid, whose density differs but slightly from that of fused stearine, must have a formula and an equivalent weight about one hundred times that which we deduce from the density of acetic acid vapor, $C_4H_4O_4$.

Starting from these high equivalent weights of liquid and solid hydrocarbonaceous species, and their correspondingly complex formulas, we become prepared to admit that other orders of mineral species, such as oxyds, silicates, carbonates, and sulphids, have formulas and equivalent weights corresponding to their still higher densities, and we proceed to apply to these bodies the laws of substitution, homology, and polymerism, which have so long been recognized in the chemical study of the members of the hydrocarbon series. The formulas thus deduced for the native silicates and carbon-spars show that these polybasic salts may contain many atoms of different bases, and their frequently complex and varying constitution is thus rendered intelligible. In the application of the principle of chemical ho-

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mology, we find a ready and natural explanation of those variations, within certain limits, occasionally met with in the composition of certain crystalline silicates, sulphids, etc., from which some have conjectured the existence of a deviation from the law of definite proportions, in what is only an expression of that law in a higher form.

The principle of polymerism is exemplified in related mineral species, such as meionite and zoisite, dipyre and jadeite, hornblende and pyroxene, calcite and aragonite, opal and quartz, in the zircons of different densities, and in the various forms of titanic acid and of carbon, whose relations become at once intelligible if we adopt for these species high equivalent weights and complex molecules. The hardness of these isomeric or allotropic species, and their indifference to chemical reagents, increases with their condensation, or in other words, varies inversely as their empirical equivalent volumes; so that we here find a direct relation between chemical and physical properties.

It is in these high chemical equivalents of the species, and in certain ingenious, but arbitrary assumptions of numbers, that is to be found an explanation of the results obtained by Playfair and Joule, in comparing the volumes of various solid species with that of ice; whose constitution they assume to be represented by HO, instead of a high multiple of this formula. The recent ingenious but fallacious speculations of Dr. Macvicar, who has arbitrarily assumed comparatively high equivalent weights for mineral species, and has then endeavored, by conjectures as to the architecture of crystalline molecules, to establish relations between his complex formulas and the regular solids of geometry, are curious, but unsuccessful attempts to solve some of the problems whose significance I have here endeavored to set forth. I am convinced that no geometrical groupings of atoms, such as are imagined by Macvicar, and by Gaudin, can ever give us an insight into the way in which nature builds up her units, by interpenetration and identification, and not juxtaposition of the chemical elements.

None of the above points are presented as new, though they are all, I believe, original with myself, and have been, from time to time brought forward, and maintained, with numerous illustrations, chiefly in the American Journal of Science, since March, 1853, when my paper on the Theory of Chemical Changes and Equivalent Volumes, was there published. I have, however, thought it well to present these views in a connected form, as exemplifying my notion of some of the principles which must form the basis of a true mineralogical classification.

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ART. XXV.—*The Repsold Portable Vertical Circle;* by CLEVELAND ABBE.

THE progress of practical astronomy in the United States has already been distinguished by the suggestion of quite new ideas, as well as by improvements upon methods and instruments in use in Europe. It seems that a part of our national mission is to give a full and free development to whatever of good can be transplanted here from abroad; it is therefore unpardonable in us to neglect any opportunity of acquainting ourselves with the results of the experience of the astronomers of the Eastern hemisphere. The history of the brilliant life of F. G. W. Struve, to whom the world is indebted for the observatories of Dorpat and Poulkova, is doubtless familiar to all. The school of practical astronomy and geodesy that grew up under him at these two places, and is now officially established at the Central Observatory for the benefit of the Imperial Military Academy and other departments of the government, has, by the extent of the astronomical and geodesical works executed, made its influence felt far beyond the dominions of the Russian Czar. A residence of nearly two years at this Observatory has impressed the writer most deeply with the correctness of that general opinion, which for years has instinctively pointed to this magnificent institution as the head-quarters of the practical astronomy of the present day.

The extent of the territory of the United States, and the oft-recurring demand for accurate topographical maps, will increase the interest with which we study the levels, barometers, base apparatus, universal instruments, vertical circles, prime vertical and extra-meridional transits, with which the Russian astronomers have sought to meet the demands made upon them. With them, as with us, celerity is of equal importance with accuracy. The extent of their territory must forbid them, as that of ours does us, from contemplating a minute triangulation of its entire superficies—such as the smaller and more densely populated territories of the British Isles and the central European states both allowed and demanded. Our national government has rightly apprehended the importance of having the most accurate charts possible to be made of our extended Eastern and Western borders; of similar importance is the survey of our inland fresh-water lakes, now in the hands of the engineers of the War Department; of great value also is the accurate survey of international boundary lines,—but the general survey and mapping of the interior presents a problem not dissimilar from that which is being solved by the Russian geographers for their own land.

It was early seen that if astronomical determinations of *relative*

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position could be made accurate to within one or two seconds of arc, the central points of reference being referred with much greater accuracy to each other and to a very few zero points, then would these relative positions, as derived from astronomical observations combined with an accurate knowledge of the figure of that portion of the earth's surface covered by these stations, suffice as groundwork for supplying the present wants of geographers and topographers. Inspired by the magnitude of the work, and supported by an interested military government, Struve and Tenner, co-working with the Norwegian and Swedish governments, carried out the astronomical and geodetical work recorded in the "Arc du Méridien de 25° 20′ entre le Danube et la mér Glaciale"—at present under the authority of O. Struve and General Baeyer, co-working with Great Britain and Belgium; the field operations connected with the measurement of the arc of longitude between Valentia and Orsk are being rapidly pushed forward and will be finished in the summer of the present year. These two great works, and the similar ones that may be expected to follow in future years, when the surveys of the immense regions of Asiatic Russia come to be connected with the surveys now being carried on by the British government, furnish the necessary determination of the figure of the earth for that portion of the globe: they find their counterparts in the geodetic astronomic works in progress or already executed upon our Atlantic and Pacific sea-board, which will afford us determinations of arcs of latitude between the parallels of 26° and 48° north, and ought to be extended to the measurement of arcs of longitude of 60° on our northern, and 40° on our southern boundaries, or possibly one of 45° between Washington and San Francisco. Up to the present decade it must be conceded that the attention of geodesists has been perhaps too exclusively directed to the measurements of degrees of latitude; it is now become important to determine also arcs of longitude, and the present European international undertaking is one worthy of emulation. It is indeed with peculiar pleasure that we notice the comparatively slight expense that would attend the junction of the present and proposed triangulations of the lake survey and of the coast survey, by a triangulation from Buffalo to Albany, leading thereby to the measurement of an arc of 18° on the parallel of 42° north between Chicago and the extremity of Cape Cod. At some future time the junction of the northwest end of Lake Superior and Cape Breton will become equally feasible, whence will result an arc of 33° on the parallel of 46° north. By the junction of the coast survey operations on the gulf of Mexico with the Pacific coast, taking advantage of the labors performed by the Mexican Boundary Survey we may be led to an arc of 33° on the parallel of 31° north, and the continuation

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westward of the survey of the lakes, or rather the completion of the labors of N. W. boundary survey should lead to the determination of an arc of 55 to 60 degrees of longitude—the largest probably that will ever be measured on this continent. In former years the difficulties in the way of accurate longitude determinations may well have prevented such undertakings as those here suggested,—but at present the telegraph and chronograph and the use of accurate extra-meridional transits have undoubtedly removed those obstacles; as regards latitudes, it is probable that the Repsold portable vertical circle will long suffice for measurement of vertical angles. It is, however, imperatively necessary in determinations of longitude, that not only the observers be exchanged, but also with them their transits, their relay batteries, chronometers and chronographs, and all apparatus used at either end.

The quadrangular area of the United States (whose natural nucleus is probably found in St. Louis or Omaha City—even as for the present state of population Cincinnati may be regarded as a central point), offers the same variety of hills and mountains, plains and plateaus as is found in Russia, and by its extent requires that the curvature of its surface be determined independently of the investigations made in the eastern hemisphere. Until this is done, the topographical surveys made by the land commissioners and surveyors of the Federal government, and by the several states, ought to be considered as plane table sheets whose fundamental points (the secondary points of a triangulation), can only be properly fixed by geodetic and astronomic measurements.

The accurate, convenient, speedy and economical determination of the positions of as many of these *secondary* stations as are needed for topographical maps that do not pretend to a pedantic accuracy is the present problem;—and assuming that the coast survey will give us a sufficient knowledge of the curvature of our portion of North America, we shall arrive at a solution of our present problem by selecting central or primary astronomical stations at convenient points—for instance, one to three in each of the states east of the Mississippi, and traversed by several railroads or navigable rivers. The astronomical latitude of these primary points, and their longitudes relative to each other and to the zero point—Washington Observatory—are to be determined with all attainable accuracy. Expeditions starting from one such point (and consisting of one observer, one vertical circle, five to twenty-five chronometers, including one non- and one over-compensated, one barometer, &c.), visiting in the course of five to twenty-five days five, ten, twenty secondary stations, and returning to the same or another primary station, will be able to furnish the relative position of all the secondary points visited

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to within two seconds of arc; or to be more definite, to within 0″·5 in latitude and 0ˢ·1 in longitude, and to give equally approximate determinations of the relative vertical heights. That this is practically done by the Russian geodesists (the first expedition dates 1846), and that in our own easily traversed country it can be better done than in theirs, is sufficient reason for calling attention to the work of Colonel Smyssloff, mentioned below, where "are fully detailed the different astronomico-geographical methods of determining position, which, by the influence of the Poulkova Observatory, have been introduced into the geodetic work of the Russian empire, and which with perfect success supplant the far more tedious and costly triangulation."*

In the wilds of Central Asia and Siberia, as in some portions of our own territory, preliminary surveys based on observations made with the pocket chronometer and Pistor and Martin's patent sextant, may supply our present need of information; but eastward to the Ural and Caucasus, it has been found practicable to transport the Repsold vertical circle and the Brauer's extra-meridional transit. The methods of using these two instruments are fully given in the two following publications:

Repsoldov Krug, Chronometri, Chronometretscheska Expedaitsir, 1859, goda. P. Smyssloff, S. Peterbourg, 1863.

Die Zeitbestimmung, vermittelst des Tragbaren Durchgangs Instruments im Verticale des Polarsterns, von W. Döllen, St. Petersburg, 1863.

A third memoir by Colonel Smyssloff (now Director of the Observatory at Wilna),

Opuity dla sravnayteljnoi otejenkay raslaytschnech sposoboff telegraphay-tscheskoi peredatschay vraymayne pray opredjelaynie rasnoste dolgote Poulkovskoi ay Moskovskoi Observatorie. P. Smyssloff, St. Petersbourg, 1865,

gives the details of the latest and telegraphic determination of the difference of longitude between the observatories of Poulkova and Moscow. This determination was made previous to the completion of the new portable transits by Brauer, and is valuable on account of the comparison of the three methods of communicating and observing the telegraphic signals.

The excellencies of the method given in the above quoted memoir by Mr. Döllen have during the past three years found confirmation in the observations conducted by the military officers studying with him. It merits a wide circulation in our own land, which I hope to secure by a published translation with appropriate tables; questions of secondary importance seem to have prevented its exclusive adoption in the longitude determinations needed for the arc of 68° 54′ on the parallel of 52° north latitude. The surprising reliability of the portable transits made by Mr. Brauer, the mechanic of the Central Observatory, now independently established in St. Petersburg, has shown them to be adapted to the highest requirements of the present state of

* Otto Struve, Jahresbericht, June 14, 1863.

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geodesy, whilst the great saving of time when they are used in the vertical of Polaris gives these instruments a remarkable superiority over the meridian transit, affording a full confirmation of the thesis propounded on page 13 of the above named memoir by Mr. Döllen, "under all circumstances, the determination of time for any given instant will be best made by mounting the portable transit, not in the plane of the meridian, but in the vertical of the pole star." Mr. Brauer has intimated to me his intention to place his sixth transit on exhibition at the Paris Exposition. Nor can I here refrain from expressing my conviction of the great importance to the interests of our astronomy and surveying to be attached to the establishment in this country of a mechanical institute, which, under the charge of a person of the experience of Brauer and the Repsolds, shall be able to furnish us with measuring instruments comparable with the objectives produced by our opticians, and fitted to do the fine work in which the astronomer and geodesist are so much interested.

For the determination of latitude the same portable transit, by being established in the plane of the prime vertical, yields zenith distances whose accuracy is in general much greater than that of the declinations of the stars observed, since these are in general faint ones. The portable prime vertical transit loses therefore somewhat of its importance, excepting for determinations of latitude where the highest accuracy is sought, and when by the coöperation of fixed observatories, special simultaneous investigations into the declinations of the stars observed can be obtained.

In general, the use of the prime vertical transit restricts one to the observation of a limited number of faint stars situated in a narrow belt. The use of the Talcott zenith telescope demands more accurate declinations of faint stars than are generally accessible, and the increased size of the telescope as well as the time required for making a large number of observations on favorable nights, constitute objections to the use of both those ingenious methods in latitudes greater than 45° (Poulkova is in latitude 60° N.), where the period favorable for field operations is comparatively short, and distinguished by long twilight.

The observations of azimuths or of zenith distances are adapted to the determination of time and latitude; and if we adopt the principle that a small number of accurate observations is preferable to a larger number of less accurate ones, it becomes necessary to restrict our attention to the three or four hundred brighter stars whose present places are known with considerable accuracy. The portable vertical circle offers itself to us as an instrument equally applicable in all latitudes to the determination of latitude, and fit for the determination of time for secondary stations between 70° of latitude and the equator, if accurately constructed as by Repsold, and used so as to eliminate

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constant or systematic errors. By reason of the ease with which it is put in position, and the brightness of the stars observed, as well as by the accuracy of its divided circles, level and microscopes, there is no time lost nor money expended in building stations, nor in waiting for nightfall, nor in tedious repetition of observations. Some of the principles embodied in the Repsold construction of this instrument may be found introduced into other instruments previously constructed for Struve by these artists, by Ertel, by Brauer, &c.; but the first of those on the perfected pattern now adopted was constructed in 1851, from designs furnished† by His Excellency, Otto Struve, the present Director of the Central Observatory. This one belonged to the topographical staff of the Imperial Military Academy, and was destined to be used in the surveys of the Caucasus; it could therefore only be once used in the new revision of the latitudes of the thirteen principal points of the Russian-Scandinavian arc; the results for that one station, Kilpi Mäki, 1852, afforded, however, a very satisfactory proof of the quality of the instrument. The considerable number of these instruments already made by the Messrs. Repsold, (and especially the fine one ordered for the hydrographical staff, and into which were introduced a number of minor improvements suggested by Mr. Brauer), have by their continual use and their successive improvement, led to the belief that the vertical circle has as yet but begun its course of usefulness, and will, with further improvements, eventually be entirely depended on for doing the work that it is so admirably fitted to accomplish,—and farther, that the principles carried out in its construction, i. e., compactness, high magnifying powers, reversibility, &c., have received authoritative confirmation as to their correctness.

The first of the memoirs of Colonel Smyssloff above quoted gives a detailed description of the instruments used and the work done in a chronometric expedition carried out by himself in 1859, in the neighborhood of Poulkova, in which seventeen points were accurately determined between the 18th of June and the 31st of July. We shall here give a brief account of the vertical circle used and of the plan of the expedition.

The aperture of the telescope used was $1\frac{1}{8}$ inches with a focal length of 20 inches—these dimensions, especially the aperture, have in later instruments been somewhat increased. The conical tube holding the objective is $9\frac{1}{8}$ inches long, being screwed to the cube containing the prism of total reflection whose center is 5 inches distant from the two Ys in which the pivots of the axis rest, and $9\frac{1}{2}$ inches distant from that end of the steel axis that carries the two parallel wires midway, between which the observed star is to be brought. The opposite end of the axis being perforated admits light for the illumination of the field.

† See Arc du Meridien. Introd., p. xxxviii.

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The bisection of a star by a single wire presents serious disadvantages in attempting observations in strong twilight on faint stars, and is not generally attempted. The wires are stretched across the end of a cylindrical tube, whose independent connection with the axis isolates it as far as possible from the exterior and protecting cylinder carrying the ocular. On either side of the cube and clamped to it by outer plates are the two circles having each 8 spokes and divided silver arcs of 11 inches diameter.

The supporting arms, whose extremities form the Y's, branch from a conical column 6 inches high; this is hollow, and within is the vertical axis on which the reversion takes place from circle and observer east to circle and observer west, or *vice versa*. This vertical axis rests upon three horizontal legs through whose extremities pass the foot screws with divided heads. The distance from the foot screws to the center axis of the instrument is about 7 inches; the whole height from the ground to objective when pointed to the zenith being two feet and two inches. The weight of the instrument is probably about forty pounds.

A horizontal finding circle with two verniers and slow-motion screw is attached to the vertical column just above the plane of the horizontal legs. The vertical circle on the side of the cube opposite to the ocular is used as a finding circle and for giving the slow vertical motion; it is provided with two pointers at the opposite ends of a horizontal bar which rests upon the horizontal axis of revolution just within the pivot, and which is held in position by a suspended vertical frame held by an adjusting screw six inches below the axis. A similar horizontal bar similarly placed near the other pivot carries the level and the two reading microscopes which are perpendicular to the plane of the circle.

In observing, therefore, the eye being directed through the telescope ocular, one has the microscopes on the left and right in a horizontal line, distant from the eye some 5 or 6 inches, whilst the level is directly in front, which convenient compactness greatly facilitates the observations.

The heads of the micrometer screws of the microscopes are divided into 60 parts each representing 2″; the level divisions have the same value. The microscopes are about 6 inches long, having single lenses of aperture 0·2 inches for their objectives, and a magnifying power of 20–25 diameters, that of the telescope being 60–65 diameters. In the present construction of the microscopes, following a suggestion of Mr. Marth in his article on the Greenwich Transit Circle, each micrometer screw is made to carry two pairs of parallel wires, the centers of the pairs being distant 1½ revolutions of the screw from each other. The image of the divided limb, which is formed in the plane of the micrometer threads, is enlarged about 3·5 times, corresponding therefore to a circle whose radius is the same as the focal length of the telescope objective.

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By comparing these dimensions with those of the four times larger Ertel vertical circle of the Central Observatory, it is evident that the portable instrument, for which the actual probable accidental error of a meridian zenith distance resulting from two pointings, one circle east and one circle west, is $\pm 0''\cdot 5$, has derived a decided advantage from its small size and proportionately higher magnifying power.

Recognizing the principle that in an astronomical measurement the fewest possible assumptions must be made,—and that computed probable errors give a very unreliable or perhaps no indication of the extent to which the constant or systematic errors introduced by assumptions as to the condition of the instrument, &c., may have vitiated our results,—it is necessary not only to examine thoroughly the instrument itself, but also in using it to still farther reduce the influence of its imperfections. Therefore a zenith distance is made to depend upon eight pointings of the telescope (or 4×8 pointings of the microscope micrometers), the four in one position of the circle being preceded and succeeded by two in the opposite position; the whole series requiring from sixteen to twenty-four minutes for its complete observation. A latitude or a time determination depends upon a pair of stars observed on opposite sides of the zenith at the same zenith distance; or upon sixteen pointings whose result is sensibly free from any assumption as to the zenith point, flexure or refraction.

The examination of the instrument used by Colonel Smyssloff leads to the following results.

The error of bisecting the interval between the two wires of either pair in the field of view of the microscope by a division of the limb of the circle, the error arising from accidental errors of the screw and the divisions of the screw head, and the error of reading these divisions, combine to affect the mean of four measurements with the microscopes, $\pm 0''\cdot 17$

The probable accidental error of a division of the divided circle, $\pm 0''\cdot 46$, affects the mean of four, $\pm 0''\cdot 23$

The probable accidental error of a reading of the two ends of the level bulb, $\pm 0''\cdot 12$

The combination of these gives

$$\sqrt{(0''\cdot 17)^2+(0''\cdot 23)^2+(0''\cdot 12)^2}=\pm 0''\cdot 31.$$

The probable accidental error of pointing on a star may be afterward investigated,—but if we assume that it equals an apparent visual angle of 1′, this will correspond to an arc of $\pm 0''\cdot 67$. Whence

$$\sqrt{(0''\cdot 31)^2+(0''\cdot 67)^2}=\pm 0''\cdot 74.$$

A zenith distance depending on one pointing, circle right, and

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one, circle left, may therefore be expected to be affected with an accidental error of

$$\frac{\pm 0''\cdot 74}{\sqrt{2}} = \pm 0''\cdot 52;$$

and for one depending on eight pointings we have a probable accidental error, $\pm 0''\cdot 26$. A latitude or time determination depending on two such zenith distances has accordingly the probable accidental error of observation, $\pm 0''\cdot 18$.

The influences of refraction, clock correction, flexure, periodic errors of division, still remain. The latter have not, to my knowledge, as yet been specially investigated,—the circles are divided with the same machine used in dividing the small circles investigated by Struve in Dorpat. See his "Beschreibung der Breite Gradmessung," and the "Description de l'Observatoire Central." The combined influence of all disturbing causes can be investigated by a series of determinations of the latitude of any known station,—the zenith point of the divided circle being successively altered by arcs of 30° or 45°. Sixteen determinations of the latitude of Poulkova afford an example of this investigation which should be entered into by each observer for his own instrument. Using the declinations given in the British Nautical Almanac, there results the following series of values of the latitude of the station, which was the northeast small dome on the grounds at Poulkova, and whose latitude, by reference to that of the Ertel vertical circle as deduced by Dr. Peters, is +59° 46′ 20″·02. Each of the following values of φ results from one observation consisting of eight pointings upon the respective stars.

Zenith point of the circle —0°.

	Star observed.	Meridian zen. dist.	Resulting latitude.	Means by pairs.
			59° 46′	
1.	β Urs. Minoris	−14° 58′	18″·77	19″·89
	α Cygni	+15 0	21 ·01	
2.	β Urs. Min.	−14 58	18 ·64	19 ·55
	α Aurigæ	+13 55	20 ·46	
3.	Polaris	−31 41	20 ·27	20 ·43
	α Coronæ	+32 35	20 ·59	
4.	Polaris	−31 41	19 ·72	19 ·98
	α Coronæ	+32 35	20 ·24	
5.	β Urs. Min. s. p.	−45 30	21 ·66	20 ·50
	α Tauri	+43 33	19 ·35	
6.	β Urs. Min. s. p.	−45 30	21 ·44	20 ·46
	α Tauri	+43 33	19 ·47	
7.	α Aurigæ s. p.	−74 23	21 ·92	20 ·53
	α Virginis	+70 12	19 ·14	
8.	α Aurigæ s. p.	−74 23	21 ·46	19 ·88
	α Virginis	+70 12	18 ·29	
	Mean of 8 pairs,			20 ·15
	" 16 "			
	By reference to the Ertel circle,			
	Difference,			

Zenith point of the circle —90°.

	Star observed.	Meridian zen. dist.	Resulting latitude.	Means by pairs.
			59° 46′	
9.	β Urs. Min.	−14° 58′	19″·54	20″·86
	α Cygni	+15 0	22 ·19	
10.	β Urs. Min.	−14 58	18 ·73	18 ·98
	α Aurigæ	+13 55	19 ·24	
11.	Polaris	−31 41	20 ·31	20 ·04
	α Coronæ	+32 35	19 ·78	
12.	Polaris	−31 41	19 ·13	19 ·34
	α Coronæ	+32 35	19 ·54	
13.	β Urs. Min. s. p.	−45 30	22 ·24	20 ·88
	α Tauri	+43 33	19 ·51	
14.	β Urs. Min. s. p.	−45 30	21 ·48	20 ·24
	α Tauri	+43 33	19 ·01	
15.	α Persei s. p.	−70 52	22 ·98	20 ·15
	α Virginis	+70 12	17 ·32	
16.	α Persei s. p.	−70 52	21 ·73	20 ·20
	α Virginis	+70 12	18 ·66	
				20 ·08
			+59° 46′ 20″·12	
			59 46 20 ·02	
			0 ·10	

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Assuming the 16 values resulting from the 16 pairs to be free from flexure, there results a probable error of latitude from one pair $= \pm 0''\cdot35$.

The difference of the latitudes resulting from the two stars of each pair depends upon the flexure of the tube and the error in the declinations, as well as upon any systematic error in the refraction or the graduation, though this is probably insensible. Assuming the latitude to be 59° 46′ 20″·00, we find the differences from this to be represented by the formula

$$\text{(A.)} \qquad +3''\cdot16 \sin(z - 30^\circ\cdot3);$$

applying this to each of the thirty-two observations, there results a probable error of a latitude from two stars $\pm 0''\cdot34$. From the sixteen values of the flexures we derive a probable error resulting from the error in the ephemeris and the error of pointing and reading; this is $\pm 0''\cdot31$. And subtracting the latter source of error, there results $\pm 0''\cdot25$ as the probable error of the declination in the British Nautical Almanac.

The investigation of flexure might also be made by means of observations in the prime vertical, but here we probably have a complicated combination of flexure and personal equation. Eight determinations of time made by Colonel Smyssloff (each depending upon eight pointings on each of a pair of stars observed in the prime vertical), compared with simultaneous observations by Wagner at the Ertel transit gave

$$\text{Wagner–Smyssloff} = -0^s\cdot02 \pm 0^s\cdot03;$$

the probable error of a single determination resulting $= \pm 0^s\cdot09$; or, if we allow equal accuracy to each instrument, the probable error of a clock correction given by the vertical circle $= \pm 0^s\cdot06$.

A series of comparisons between Messrs. Smyssloff, Bolscheff and Demetrieff, in which each observed four of the eight pointings gave,

$$\text{S.–D.} = -0^s\cdot098,\ \text{S.–B.} = -0^s\cdot046,\ \text{B.–D.} = +0^s\cdot132;$$

and the probable error of a determination of time $= \pm 0^s\cdot06$, which in the latitude 60° corresponds to a vertical angle of $\pm 0''\cdot45$.

As in the determination of latitude so in that of time, a pair of stars equally distant from the zenith is always observed, each being pointed upon four times in each position of the circle, the eight pointings requiring twenty minutes or less. The stars are of course observed near the prime vertical.

[To be concluded.]

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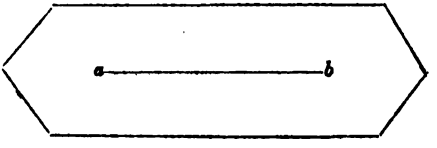
ART. XXVI.—*On Cryophyllite, a new mineral species of the Mica Family, with some associated minerals in the granite of Rockport, Massachusetts;* by JOSIAH P. COOKE, Jr.

IN a paper published in a recent number of this Journal* I described a new mineral species allied to Helvin, to which I gave the name of Danalite. Associated with Danalite in the granite ledges forming the extremity of Cape Ann, Massachusetts, are two remarkable micas, one of which is the new species to which on account of its easy fusibility and foliated structure I have given the name Cryophyllite.

Mineralogical Characters.—The mineralogical characters of cryophyllite are as follows. Like other varieties of mica it crystallizes in six-sided prisms, which are frequently of considerable size, from one to two inches in length and of proportionate diameter. The basal cleavage is highly perfect, yielding thin flexible and transparent laminæ, which when examined with a polarizing microscope give a biaxial image, the angle between the optical axes varying from 55° to 60°. The angles 55°, 57° 30′, and 60°, were all measured on different specimens. The dispersion of the axes, if any, is so slight that its character could not with certainty be determined, the color of the mineral tending to obscure any such effect. The perfect uniformity of the two systems of rings both as to form and to color indicates that the mica belongs to the trimetric system. Nevertheless, the angle between the prismatic planes measured with an application goniometer 120° as accurately as is possible with this instrument, and in one instance the planes of an hexagonal pyramid terminating the prism were distinctly seen. Considering, however, these crystals as belonging to the trimetric system, in accordance with the generally received opinion of mineralogists as to crystals of the mica family, all of which present essentially the same crystallographic characters, we must regard the six-sided prism of cryophyllite as formed by the union of the planes *I* of the rhombic prism with the brachydiagonal basal planes $i\bar{i}$. The plane of the optical axes coincides with the shorter diagonal of the rhomb base, and the crystals are frequently much elongated in this direction, so that the form of the cleavage face was as shown in the accompanying figure, the line *a b* indicating the position of the plane of the optical axes. Furthermore, the crystals were frequently twinned together on the plane $i\bar{i}$, and it was observed that in such cases the planes



* Vol. xlii, No. 124, July, 1866.

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of cleavage of the two crystals were absolutely coincident, proving that the rhombic prisms are rectangular and not oblique, as De Senarmont has previously shown to be true of other crystals of the mica family.

The color of cryophyllite in axial directions is dull emerald green, not unlike glass colored with protoxyd of iron, and so deep that the laminæ are opaque unless quite thin, but like other colored micas it is dichrous and appears brownish-red in the direction of the lateral axes. The color of the streak is light gray with a tint of green. The luster is brilliant on the cleavage face inclining to resinous. The hardness is from 2 to 2·5 and the specific gravity 2·909.

Before the blowpipe cryophyllite very easily fuses with some intumescence to a greyish enamel bead, and it even fuses in flakes of considerable size in the flame of a candle, so that its fusibility is from 1·5 to 2 of von Kobell's scale. It imparts to the flame of a Bunsen's lamp a most brilliant lithia reaction, and by examining the colored flame with a spectroscope the presence of potassium, sodium and rubidium may also be readily discovered. The amount of sodium however must be exceedingly small as it does not sensibly modify the lithia flame as seen by the naked eye, and the same is true to a still greater degree of rubidium. The presence of rubidium is best recognized by mixing the pulverized mineral with pure pulverized sulphate of lime, exposing a small bead of this mixture supported by a loop of fine platinum wire to the flame of a gas blowpipe and examining the flame with a spectroscope. The characteristic double blue line of rubidium is then seen very distinctly for a few moments, but soon disappears. No trace of cæsium could be discovered, either by the mode of experimenting just described or by examining the platinum salt obtained in the course of the analysis, by the partial precipitation of the alkalies with chlorid of platinum.

Heated alone in a closed glass tube cryophyllite slightly changes color, but gives no sublimate, although when heated in the same with bisulphate of potash it gives a strong reaction of fluorine. When in fine powder, it is completely decomposed after some time even by the dilute mineral acids, the silica separating as a fine powder. From this description it is evident that in its mineralogical characters cryophyllite closely resembles other members of the mica family, especially the lepidolites, differing from these chiefly in the ease with which it is decomposed by acids and in a somewhat greater fusibility.

Method of Analysis.—In analyzing the mineral the fine powder was decomposed in a closed glass flask in the same way as described in my paper on Danalite, using dilute hydrochloric or sulphuric acids as the case required. Each complete analysis was made with three portions of the same powder. From the first

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portion, decomposed by hydrochloric acid, the silica, manganese, iron and aluminum were determined, the last two being precipitated as basic acetates and weighed together, as oxyds, and the manganese subsequently precipitated from the filtrate by bromine. From the second portion, decomposed by dilute sulphuric acid, with perfect exclusion of air, the amounts of protoxyd and sesquioxyd of iron were determined by means of permanganate of potash, when by subtracting the total quantity of iron, calculated as sesquioxyd, from the sum of the alumina and sesquioxyd of iron already known, the amount of alumina was ascertained. From the third portion of the powder, decomposed by hydrochloric acid, the magnesia and the alkalies were determined. The alkalies were weighed as sulphates, and from the amount of sulphuric acid subsequently determined, the relative quantities of potash and lithia were calculated. From the fourth portion of the powder the quantity of fluorid of silicon was determined. In the first analyses of the mineral the fluorine was precipitated as fluorid of calcium according to the well known method of Berzelius as modified by Rose; but the process was found to be very tedious and the results not accordant. Subsequently the following method was devised, which may be found to be useful in other cases.

Determination of Fluorid of Silicon.—A weighed amount of finely pulverized mineral is first decomposed in a tared platinum dish with dilute sulphuric acid, and the greater part of the water having been removed on a steam bath and the excess of sulphuric acid having been driven off by gradual heating on a sand bath, the whole mass is ignited during at least an hour, the dish meanwhile being covered with a piece of platinum foil forming part of the tare. The dish with its contents having been weighed, the dried mass is next treated with hydrochloric acid and the residual silica determined in the usual way, and in the filtrate from the silica the sulphuric acid is determined and weighed as sulphate of baryta. We thus obtain four weights: A, the weight of the mineral employed in the analysis; B, the weight of the ignited residue; C, the weight of the residual silica; and D, the weight of the residual sulphuric acid. It is now evident that $A+D-B$ equals the weight of the fluorid of silicon, and that $B-C-D$ equals the weight of the sum of all the bases present. The iron is of course present in the residue as sesquioxyd, but in order to ensure its complete oxydation, it is important to add a few drops of nitric acid to the decomposed mineral, before expelling the excess of sulphuric acid. The sum of the weights of all the bases, which we find incidentally as one of the results of this method, not only furnishes an important control of the rest of our analysis, but also enables us to test the accuracy of our method. In the analysis given below it appears that the

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sum of the bases each separately determined as the mean of two analyses equals 45·03 per cent, while the sum of the bases weighed together in the method just described equals 45·18 per cent, as the mean of three determinations. A closer agreement than this could not possibly be expected. The process is comparatively short and presents no unusual difficulties. The chief liability to error is in the determination of the sulphuric acid, and it is necessary in washing the sulphate of baryta to take great care to remove the impurities, which this precipitate is apt to carry down; but the methods recommended by Rose and Fresenius were found to be generally sufficient for the purpose. Nevertheless, when the amount of fluorine is less than one per cent, the old process is to be preferred.

Results of Analysis.—Two very distinct varieties of cryophyllite were analyzed,—the one finely foliated and consisting of an aggregate of small crystals and the other in large distinct crystals imbedded in massive feldspar; but no other differences of character were observed, and they were found to have the same percentage composition. The purest material was selected for analysis and such as had evidently never undergone the slightest change. There is probably in all the analyses a small loss of silica, but the error, if any, is in that direction. The results are given in the following table. In columns 1 and 2, we have the complete analyses made as first described of the large crystals, while in columns 3, 4 and 5, we have the partial analysis made of the more finely foliated variety by the process last described in connection with the determination of fluorid of silicon.

Analysis of Cryophyllite from Rockport.

	1.	2.	3.	4.	5.	Mean.	Oxygen.
Silica,	51·53	51·54	51·65	51·37	51·36	51·49	27·46
Fluorid of silicon,			3·29	3·34	3·62	3·42	1·06=28·52
Alumina,	16·76	16·77				16·77	7·82
Sesquioxyd of manganese,	0·33	0·35				0·34	0·10
Sesquioxyd of iron,	2·00	1·94				1·97	0·59= 8·51
Protoxyd of iron,	8·00	7·96				7·98	1·76
Magnesia,	0·76		45·06	45·29	45·02	0·76	0·30
Potassa,	13·14	13·16				13·15	2·23
Lithia,	4·05	4·06				4·06	2·16= 6·45
Soda,	*trace.*					*trace.*	
Rubidia,	"					"	14·96
						99·94	

Oxygen ratio, 14·96 : 28·52

14·26 : 28·52=1 : 2.

General formula, RO, SiO_2. Probable rational formula, $(\frac{1}{3}\dot{R}^3 . \frac{1}{3}\ddot{R}), 3\ddot{S}i)$.

The fluorine in the mineral is so firmly incorporated that, as stated above, it is not driven out even by a red heat, and there can be no doubt that it replaces a portion of the oxygen of the silica in the proportion of one equivalent of fluorine to every twenty-eight of oxygen. The ratio of the oxygen of the prot-

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oxyds to that of the sesquioxyds is as 13 to 17, but if we estimate all the iron as protoxyd, assuming with many mineralogists that a sesquioxyd base may under certain conditions replace a protoxyd base, we shall then have very nearly a ratio of equality and may then write our general symbol $(\frac{1}{2}\dot{R}^3 . \frac{1}{2}\dddot{R})_3 \dddot{Si}$.

As has already been stated, the physical characters of the new mineral do not differ essentially from those of other well known micas, and even its greater fusibility is shared with some varieties of lepidolite, resulting probably from the very large amount of alkali which the silicate contains. The ground on which this mica must be regarded as a new species is the definite oxygen ratio of 1 to 2, which has never before been observed among the micas. The five analyses given above of two distinct varieties, from different localities, differing markedly in appearance, leave no doubt in regard to the definiteness of this ratio, and no more specific character for a new species than this could be desired. When now we consider the very great want of definiteness in the micas as a class, their composition varying between $2RO, SiO_2$ in several varieties, and RO, SiO_2 in cryophyllite, it would appear that the new mica has a distinct typical character, forming as it were one boundary of this family of minerals. Moreover, it is at least a probable theory that the two formulæ just given represent the only two distinct types of micas, and that the variation of composition may result from an admixture of these two isomorphous species. The masterly investigations of De Senarmont on the optical relations of the micas tend to show that such an admixture exists, and at least prove that even a very large difference in the angle of the optical axes does not afford a safe ground for making a distinction in species. He supposed that this difference arises from a mixture of two micas crystallographically isomorphous but optically distinct, the one, and the more common class, having the optical axes in the plane of the longer diagonal, while in the other they fall in the plane of the shorter diagonal, as is the case with cryophyllite. Moreover, he was enabled, by crystallizing together certain isomorphous salts, to produce artificially the same result, which we have naturally in the micas. If then the variation of optical characters results from an isomorphous mixture of *optically* distinct species, it is at least probable that the variation of composition, so far as the oxygen ratio is concerned, may be caused by a similar mixture of *chemically* distinct species, and this view may serve to bring into some sort of order the almost hopeless confusion which the analyses of micas have hitherto presented. The magnesian micas phlogopite and biotite are sufficiently distinguished by the character of their bases, and conform very closely to the general formula $2RO, SiO_2$; but there does not seem to be any good ground for distinguishing between

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the two. The optical distinction, as we have seen, is not specific, and if sesquioxyds may replace protoxyds, any apparent difference in the relative proportions of these oxyds is equally of no value as a ground of separation. Even this last difference, however, is not constant, and biotite must be regarded as a phlogopite in which a certain amount of magnesia has been replaced by protoxyd or sesquioxyd of iron. Passing next to lepidomelane, we have a pure iron mica in which all the magnesia has been in like manner replaced. Lastly, the presence or absence of a small and very variable amount of lithia does not seem to make any good ground of distinction between lepidolite and muscovite, and the only essential difference between these species is the much greater fusibility of the former, arising probably from the large amount of alkali and fluorine entering into its composition, a quality which we have endeavored to express by the name cryophyllite, following the analogy of the name cryolite. In lepidolite the oxygen ratio varies very widely between the extreme limits already named, the variation resulting, according to our theory, from a mixture of two species, the first having the type ratio 1 : 1, which we may still call lepidolite, and the second having the ratio 1 : 2, which has been described in this paper and called cryophyllite. A similar admixture of an isomorphous species having the type ratio 1 : 2 may explain the equally wide variations in the oxygen ratio of the muscovite, although the infusible mica corresponding to cryophyllite has not yet been observed. It is manifest that the theory here advanced would be very greatly substantiated if it could be shown that cryophyllite is actually associated with a distinct but isomorphous mica having the type ratio 1 : 1, and that it does actually influence the composition of its associate in the way we have indicated. Such is the case, as we believe, at the Rockport locality.

Lepidomelane.—The mica which is associated with cryophyllite at Rockport (or as we should rather say, with which cryophyllite is associated, for cryophyllite is the subordinate species) is an iron mica of the species lepidomelane. This is the common mica of the great granite ledges which form the extremity of Cape Ann. In the granite itself, however, it occurs only in small flakes forming a very small proportion of the whole mass; but in the numerous veins which intersect the rock, lepidomelane is found in crystals of considerable size and sometimes in plates several inches in diameter. The vein, from which most of the best specimens have been taken, is an offshoot of one of the great trap dikes which cross the Cape from north to south nearly parallel to each other, and consists chiefly of massive quartz and feldspar almost completely segregated, the quartz lining the lower wall, while the feldspar lines the hanging wall

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of the vein. The best crystals, both of lepidomelane and of cryophyllite, are found in the massive feldspar, sometimes in direct contact and interpenetrating each other, while at other times they are comparatively isolated. The crystals of the two minerals resemble each other so closely in their external aspect that it requires some experience to distinguish them, without applying the distinctive test soon to be mentioned, and even an experienced mineralogist might readily mistake an aggregate of the two for a homogeneous mass. Like cryophyllite the lepidomelane crystallizes in hexagonal prisms with an angle of 120° between the prismatic planes, as was measured on several specimens with an application goniometer. Moreover the crystals have the same general habitus as those of the associated mica. They are frequently seen elongated in the direction of the brachydiagonal and twinned together on the plane $i\bar{i}$, and, in a word, the description of the crystals of cryophyllite already given applies equally well to those of lepidomelane; but unfortunately on account of the great opacity of lepidomelane I have not yet succeeded in determining its optical relations. There can be no doubt, therefore, that the two micas are perfectly isomorphous. But while the outward resemblance of these micas is so striking, the mineralogical characters of the two species are wholly distinct, as will be seen from the following description.

Mineralogical characters of Rockport Lepidomelane.—The cleavage is basal and perfect, but it is not so eminent as in most micas, and the foliæ are not at all or only slightly elastic. The color is black, and that of the streak dark green, differing wholly from the color of the streak of cryophyllite, which is light gray with only a faint tinge of green. The laminæ are opaque unless exceedingly thin. The luster is very brilliant, inclining to resinous on the cleavage face. The sp. gr. was found to be 3·169, and the hardness about that of calcite, or 3. Before the blowpipe it fuses to a black enamel bead, which is highly magnetic, and this affords another ready means of distinguishing it from cryophyllite. The fusibility is about that of iron-garnet, or between 3 and 4 of von Kobell's scale. With borax it forms a bottle-green glass. The powder when heated in a closed glass tube gives off water, and its green color changes to a pinchbeck-brown not unlike that of magnetic pyrites. Heated with bisulphate of potash it gives a slight reaction for fluorine. The powder is easily decomposed by the dilute mineral acids, the silica separating in fine scales. These characters agree very closely with those of the original lepidomelane from Wermland as described by Soltmann,* only the more perfect crystals from Rockport enable us to determine the crystalline form with more cer-

* Pogg. Annalen, l, 664, also Dana's System, 4th edition, vol. ii, page 297.

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tainty than was possible with the minute scales from which the species was first established.

Analysis of Rockport Lepidomelane.—My analyses of this mica are given in the following table. In the analyses 2, 3, and 4, the same methods were followed which have already been described in connection with cryophyllite. In analysis 5, I employed, with some slight modification, the method first proposed by H. Saint Claire Deville,* and the close agreement of the figures obtained by such very different methods serves to confirm the general accuracy of the result. The determination of the water was the chief difficulty met with in the analyses. The water enters so intimately into the composition of the mineral that it is not expelled below a low red heat, and then only quite slowly. Moreover at this temperature the mineral is rapidly oxydized. But by igniting the mineral in a current of carbonic acid gas the oxydation was prevented and constant results were obtained. With this precaution portions of the same powder were ignited, first without and then with oxyd of lead with the following results:

	1.	2.	3.	Mean.
Loss on ignition without PbO,	1·54	1·52	1·52	1·53
" " with "	1·55	1·40		1·48

The difference is within the limit of probable error, and the results prove that the fluorine is not expelled at a low red heat. Moreover the mineral after ignition gave as strong a reaction for fluorine as before, and when heated to the highest temperature which could be obtained with a gas blast lamp, underwent no farther loss of weight. This is in accordance with what we found to be true of cryophyllite; but not in accordance with the comportment of hydrous minerals into which fluorine enters as an essential constituent. Compare analyses of Cookeite, this Journal, [2], xli, 246. These facts, taken in connection with the circumstance that fluorine was not found by Soltmann in the lepidomelane of Wermland, lead to the inference that the fluorine in the Rockport mineral is an accidental constituent, derived from the admixture of material foreign to the species itself. The amount of fluorid of silicon in analysis 2 was determined by the method of Berzelius; but the limit of error in this process is so wide that the result can only be regarded as approximate. The analyses which follow were all made on material dried at 100°, and selected to represent the different varieties of the mineral found at Rockport. Analyses 2 and 3 were made from portions of a mass of comparatively compact material. No. 4 from a perfect crystal imbedded in the massive feldspar of the vein already referred to, and the silica determination. No. 1 from scales picked out from the granite of Boylston Hall in Cambridge, which is built of stone from the Rockport quarries.

* Annales de Chimie et de Physique, [3], xxxviii, 5.

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Analysis of Rockport Lepidomelane.

	1.	2.	3.	4.	5.	6.	7.	8.	Mean.	Oxygen.
Silica,	39·50	39·49	—	39·79	39·43	—	—	—	39·55	21·09
Fluorid of silicon,		0·62	—	—	—	—	—	—	0·62	0·19=21·28
Alumina,		16·72	16.41	16·90	16·87	—	—	—	16·73	7·81
Sesquiox. of manganese,		—	0·63	0·58	0·59	—	—	—	0·60	0·18
Sesquiox. of iron,		—	—	—	—	12·21	12·01	11·98	12·07	3·62
Protox. of iron,		—	—	—	—	17·57	17·47	17·41	17·48	3·88
Magnesia,		—	—	0·64	0·59	—	—	—	0·62	0·25
Potassa,		—	—	10·68	10·63	—	—	—	10·66	1·81
Lithia,		—	—	0·60	0·57	—	—	—	0·59	0·32
Soda,		—	—	—	—	—	—	—	*trace.*	—
Rubidia,		—	—	—	—	—	—	—	"	—
Water,		—	—	1·55	1·40	1·52	1·52	1·54	1·50	1·33=19·20
									100·42	

Oxygen ratio, 19·20 : 21·31.

After an examination of the results of the above analyses no one can doubt that the true oxygen ratio of the mineral is 1 : 1, and that the general formula is $2RO, SiO_2$ or $2(\frac{1}{3}\dot{R}^3 . \frac{1}{3}\dot{R})3\dot{S}i$. This is not only the nearest probable formula, but moreover it harmonizes with the well established formulæ of allied species and with the results of Soltmann's analysis of lepidomelane, a mineral which our Rockport mica resembles most closely in all its characters. Nevertheless the discrepancy between the actual and the probable ratio is very great, and cannot possibly be referred to impure material or imperfect processes. As has been already stated, the material used in the fourth analysis was a portion of a perfect crystal completely isolated in a mass of feldspar, and the results of this analysis agree almost precisely with those obtained in No. 5 by an entirely different process and with wholly different material. Here then are the same unsatisfactory results, which have been obtained again and again in the analyses of the micas, and have made it so difficult to reduce to order this important family of minerals. Fortunately we find at the Rockport locality what I believe to be the clue to the whole mystery. The common mica of the granite is there associated with a second mica containing twice as much silica, but still perfectly isomorphous with it in crystalline form. Now if two isomorphous salts crystallize together from the same solution, we obtain crystals which are mixtures of the two in definite proportions, the proportions depending chiefly on the relative quantity of each which may be present; but also at times on other conditions less accurately determined.* When the sedimentary rocks were undergoing the metamorphism which converted them into the granite ledges of Rockport, or when by any other means this granite was formed, the two isomorphous micas, described in this paper, did actually crystallize together, for so we find them; and it is reasonable to suppose that the same results followed in the one case as in the other, and that

* See Rammelsberg's important paper on this subject, Pogg. Ann., xci, 321.

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the mica of the Rockport granite is an isomorphous mixture of these two distinct species. This conclusion, moreover, is favored by the fact that lepidomelane—the species to which this mica undoubtedly belongs—contains in other localities neither lithia nor fluorine; while on the other hand these same ingredients are strikingly characteristic of the lepidolite micas, to which cryophyllite is allied. Assuming then that the lithia and fluorine in the analyses belong to the cryophyllite and not to the lepidomelane, we have endeavored in the following table to eliminate this disturbing element from our results. Thus, in column 1 we have repeated the mean result of our analyses. In column 2 we have the amounts of the several ingredients of cryophyllite corresponding to 0·59 per cent of lithia, deduced from the analyses of this mineral given above. Subtracting these quantities from those in the first column we have the numbers in the third column. In column 4 we have reduced the same to a percentage composition, and these numbers, according to our theory, represent the true composition of the Rockport lepidomelane. In column 5 we have placed for comparison the analysis of lepidomelane by Soltmann.

Reduction of analyses of Lepidomelane.

	1.	2.	3.	4.	Oxygen.	5.	Oxygen.
Silica,	39·55	7·48	32·07	**37·39**	....=19·94	**37·40**	=19·94
Fluorid of silica,	0·62	0·50	....	....	....		
Alumina,	16·73	2·44	14·29	**16·66**	7·78	**11·60**	5·42
Sesquiox. of manganese,	0·60	0·05	0·55	**0·64**	0·19		
Sesquiox. of iron,	12·07	0·29	11·78	**13·74**	4·12	**27·66**	8·29
Protoxyd of iron,	17·48	1·16	16·32	**19·03**	4·23	**12·43**	2·76
Magnesia,	0·62	0·11	0·51	**0·59**	0·24	**0·26**	0·10
Potassa,	10·66	1·91	8·75	**10·20**	1·73	**9·20**	1·61
Lithia,	0·59	0·59	....	....	....		
Water,	1·50	....	1·50	**1·75**	1·56=19·85	**0·60**	0·53=18·71
				100·00		**99·15**	

Oxygen ratio, 19·85 : 19·94 = 1 : 1.

General formula $2RO, SiO_2$. Probable rational formula, $2(\frac{1}{2}\dot{R}^3, \frac{1}{2}\dddot{R})3\dddot{S}i$.

The result of our calculation, as will be seen, is most satisfactory; for not only is the oxygen ratio thus obtained exact, but also the numbers agree very closely with those of Soltmann, the only apparent discrepancies disappearing when the sum of the alumina and the oxyds of iron and manganese are compared together in the two analyses, and the difference in the distribution of the iron between the two oxyds is unimportant if we assume as before that the oxyds may replace each other. We have estimated in both analyses the amount of water among the bases for the following reasons, which seemed to us conclusive: first, because the loss of water is attended by a very marked change in the color of the mineral—from green to brown—

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proving that the water must be chemically, and not merely hygroscopically, combined; secondly, because while water of crystallization would be present in a definite number of equivalents —one or more—the quantity of water in this mineral obeys no such law, and only amounts to a small fraction of a single equivalent; lastly, because the water is only driven out at a high temperature, indicating that it is in a state of intimate combination. There does not appear to be any simple relation between the amounts of the protoxyd and sesquioxyd of bases in the Rockport lepidomelane; but the general formula of the mineral may readily be reduced to that of the magnesian micas by assuming that a portion of the protoxyd of iron has been replaced by the sesquioxyd.

The facts advanced in this paper seem to show quite conclusively that the variation in composition of the Rockport lepidomelane from the normal type is caused by the admixture of a second isomorphous mica with a higher oxygen ratio, which we have called cryophyllite, and this being the case we may expect to find that similar variations in the composition of other micas are due to a similar cause, and it will therefore be interesting to search for the disturbing element at the various localities. Such an examination will be likely to reveal either the presence of cryophyllite itself or else of some new species analogous to it; and if the Rockport locality is any guide, such minerals are more likely to be found in feldspathic veins or nodules of the granite rather than uniformly diffused through the rock itself. It is a fact worthy of notice, and which is quite evident from the above analyses, that the proportions in which cryophyllite is mixed with lepidomelane are quite constant throughout the Rockport locality; and this again is wholly in accordance with the well known facts which have been developed by Rammelsberg* and others in regard to the crystallization of isomorphous salts when mixed together in the same solution. It appears from these investigations that isomorphous salts do not necessarily crystallize together in every proportion, but that, in most cases at least, any two given salts have, so to speak, a definite capacity for each other, and that when the point of saturation is passed, pure crystals of the salt in excess may be deposited in direct contact with those which are mixtures of the two. Such experiments furnish an exact counterpart of the conditions which we actually realize in the Rockport granite.

Albite.—The general nature of the vein in which the best crystals, both of cryophyllite and lepidomelane, have been found, has already been described in the earlier part of this paper. This vein consists chiefly of quartz and feldspar of the ortho-

* Pogg. Ann., vol. xci, p. 321.

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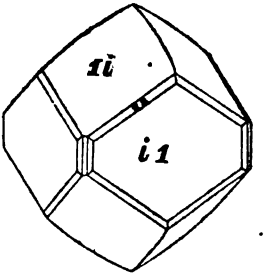
clase variety. Very fine green colored crystals of the last have been obtained here, and good crystals of the usual color are abundant. Associated with the orthoclase I have frequently noticed a compact variety of albite distinguished by a peculiar luster and very marked striation on the plane of easy cleavage. It resembles somewhat, in outward aspect, oligoclase, but the mineral had the characteristic cleavages of a clinoclase feldspar, and the angle *O* on *ii* measured with an application goniometer 93°. Moreover it contains, if any, only the merest trace of lime. The albite is actually imbedded in the orthoclase, and the intimate association of these two heteromorphous species is worthy of notice.

Malacone.—The same vein contains also a peculiar variety of zircon, which is probably identical with the malacone of Scheerer, only somewhat more altered. The crystals have the general form represented in the figure, and resemble the crystals of zircon from Expailly in France. On account of the great predominance of the planes 1*i* and *i*1, they resemble the rhombic dodecahedron of the regular system, and can only be distinguished from this form by the distribution of the modifying planes; since on account of the strong curvature of the faces the limits of necessary uncertainty in the measurement of the angles cover the whole difference between this form and the corresponding form of zircon. In the ordinary method of representing the crystals of zircon the relation of the forms just referred to does not appear; but if we refer the planes of the zircon crystals to axes corresponding in position to those of the allied form of the regular system, the really close affinity of the two becomes evident. Thus the ratio of the axes, which in the regular system is unity, is in zircon $a:b=0{\cdot}906:1$, and the angle 1*i* on *i*1, which in the dodecahedron equals 120°, is in the zircon crystal equal to 123° 19′. In the figure here given the crystal has been drawn and the planes lettered with reference to the axes of the dodecahedron, and this must be borne in mind when comparing it with other figures of zircon. The most striking peculiarity of the crystals is the strong curvature of the terminal faces, which has been indicated in the figure, and which, as already intimated, renders accurate measurements impossible. Nevertheless, within the limits of necessary uncertainty the angles measured the same as those of zircon. The small planes not lettered on the crystal for want of space are *ii* and *i*3.

2.



The color both of the crystal and the powder is brownish-red,

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and this color is not altered by ignition. Luster more or less adamantine on different specimens, evidently varying with the degree of alteration, and becoming more brilliant after ignition. Fracture after ignition conchoidal and very brilliant, but varying on the natural crystals, like the luster, with the degree of alteration. There is no distinct cleavage. Hardness before ignition from 5 to 5·5; after ignition from 7 to 7·5. Specific gravity before ignition from 3·985 to 4·040, the extreme limits observed; after ignition 4·095. Before the blowpipe the mineral is infusible. In a closed tube it gives off water, which has at first an alkaline reaction, but becomes acid when the mineral is heated more intensely. With bisulphate of potash gives slight reaction for fluorine. The powder dissolves with some difficulty in melted borax, giving only the reaction for iron. In phosphorus salt it dissolves only with great difficulty and incompletely, giving in the reducing flame, even when treated with tin on charcoal, a colorless glass. The mineral is partially decomposed by hydrochloric acid; more perfectly by strong sulphuric acid, and completely by fusion with carbonate of soda. An imperfect analysis gave the following results:

Silica, - - - - - - - -	27·90
Zirconia, - - - - - - - -	66·93
Sesquioxyd of iron with trace of manganese, -	2·57
Water, - - - - - - - -	2·19
	99·59

These numbers must give very nearly the composition of the material analyzed; but the composition must vary with the degree of alteration, and probably no two specimens would give precisely the same result. The material used was the best I could command, but not so good as might be desired, and I am happy to learn that a more trustworthy analysis will soon be published. On comparing these numbers with Scheerer's analyses of malacone, it appears that the amount of silica is somewhat greater in the original specimens, but the difference is evidently the result of further alteration. The zirconia was examined for other earths and metallic oxyds, but without positive results. No distinct indications of titanium could be obtained with the blowpipe, although it is possible that in the presence of so large an amount of zirconia a small amount might have escaped notice. The zirconia separated from the mineral was converted into chlorid, and the solution when evaporated crystallized to the last drop, forming a large mass of white silky needles. A solution of this chlorid, still acid to litmus paper, turned turmeric paper orange-yellow. In a solution of the same chlorid, oxalic acid produced a voluminous precipitate, which, when the solu-

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tion was cold, readily dissolved in an excess of the reagent, and the more readily the larger the quantity of free hydrochloric acid present. If the solution was heated to boiling during the precipitation, the precipitate was not easily redissolved; but by digesting it for several hours with a very large excess of oxalic acid complete solution was finally effected. In a similar solution of the chlorid, a strong solution of sulphate of potash produced a precipitate, which in the presence of free hydrochloric acid readily dissolved in an excess of the reagent if the solution was kept cold. But if the solution was heated during the precipitation, the precipitate did not thus redissolve; but it immediately disappeared on adding a small amount of dilute sulphuric acid. From a solution of the chlorid of zirconium, ammonia throws down a gelatinous precipitate, but this precipitation was entirely prevented by the addition of tartaric acid. The hydrate thus obtained, when heated before the blowpipe, became intensely luminous and changed into a hard granular powder insoluble in all dilute acids. After digesting it, however, for several hours in strong sulphuric acid, it was converted into a sulphate, which dissolved completely on diluting the acid with water. These reactions appear to indicate that the zirconia was quite, if not entirely, free from an admixture of other earths, and the manner in which its reactions are modified by the temperature is the probable explanation of the confusion on the subject which is found in many text-books. The two modifications of zirconia, distinguished by Berzelius, seem to be repeated in many of its compounds, and malacone stands in the same relation to ordinary zircon that the soluble oxalate and sulphate do to the insoluble varieties. The malacone at Rockport is unquestionably in process of alteration, but whether the original mineral was the ordinary zircon or what we may call the normal malacone, I have not yet been able to determine.

ART. XXVII.—*On a possible Geological Cause of Changes in the Position of the Axis of the Earth's Crust;* by JOHN EVANS, F.R.S.*

AT a time when the causes which have led to climatal changes in various parts of the globe are the subject of so much discussion, but little apology is needed for calling the attention of this Society to what possibly may have been one of these causes, though it has apparently hitherto escaped observation.

That great changes of climate have taken place, at all events in the northern hemisphere of the globe, is one of the best estab-

* Proceedings of the Royal Society, xv, p. 46.

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lished facts of geology, and that corresponding changes have not been noticed to the same extent in the southern hemisphere may possibly be considered as due, rather to a more limited amount of geological observation, than to an absence of the phenomena indicative of such alterations in climatal conditions having occurred.

The evidence of the extreme refrigeration of this portion of the earth at the Glacial Period is constantly receiving fresh corroboration, and various theories have been proposed which account for this accession of cold in a more or less satisfactory manner.

Variations in the distribution of land and water, changes in the direction of the Gulf Stream, the greater or less eccentricity of the earth's orbit, the passage of the solar system through a cold region in space, fluctuations in the amount of heat radiated by the sun, alternations of heat and cold in the northern and southern hemispheres, as consequent upon the precession of the equinoxes, and even changes in the position of the center of gravity of the earth and consequent displacements of the polar axis, have all been adduced as causes calculated to produce the effects observed; and the reasoning founded on each of these data is no doubt familiar to all.

The possibility of any material change in the axis of rotation of the earth has been so distinctly denied by Laplace* and all succeeding astronomers, that any theory involving such a change, however tempting as affording a solution of certain difficulties, has been rejected by nearly all geologists as untenable.

Sir Henry James,† however, writing to the 'Athenæum' newspaper in 1860, stated that he had long since arrived at the conclusion that there was no possible explanation of some of the geological phenomena testifying to the climate at certain spots having greatly varied at different periods, without the supposition of constant changes in the position of the axis of the earth's rotation. He then, assuming as an admitted fact that the earth is at present a fluid mass with a hardened crust, showed that slaty cleavage, dislocations, and undulations in the various strata are results which might be expected from the crust of the earth having to assume a new external form, if caused to revolve on a new axis, and advanced the theory that the elevation of mountain-chains of larger extent than at present known produced these changes in the position of the poles.

The subject was discussed in further letters from Sir Henry James, the Astronomer Royal, Professors Beete Jukes and Hennessy, and others, but throughout the discussion the principal question at issue seems to have been whether any elevation of a

* Méc. Cél., vol. v, p. 14.

† Athenæum, Aug. 25, 1860, &c.

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mountain-mass could sensibly affect the position of the axis of rotation of the globe as a whole, and the general verdict was in the negative.

At an earlier period (1848) the late Sir John Lubbock, in a short but conclusive paper in the 'Quarterly Journal of the Geological Society'* pointed out what would have been the effect had the axis of rotation of the earth not originally corresponded with the axis of figure, and also mentioned some considerations which appear to have been absent from Laplace's calculations.

Sir John Lubbock, however, in common with other astronomers, appears to have regarded the earth as consisting of a solid nucleus with a body of water distributed over a portion of its surface; and there can be but little doubt that, on this assumption of the solidity of the earth, the usually received doctrines as to the general persistence of the direction of the poles are almost unassailable.

Directly, however, that we argue from the contrary assumption that the solid portion of the globe consists of a comparatively thin, but to some extent rigid crust with a fluid nucleus of incandescent mineral matter within, and that this crust, from various causes, is liable to changes disturbing its equilibrium, it becomes apparent that such disturbances may lead, if not to a change in the position of the general axis of the globe, yet at all events to a change in the relative positions of the solid crust and the fluid nucleus, and in consequence to a change in the axis of rotation, so far as the former is concerned.

The existence in the center of the globe of a mass of matter fluid by heat, though accepted as a fact by many, if not most geologists, has no doubt been called in question by some, and among them a few of great eminence. The gradual increase of temperature, however, which is found to take place as we descend beneath the surface of the earth, and which has been observed in mines and deep borings all over the world, the existence of hot springs, some of the temperature of boiling water, and the traces of volcanic action, either extinct or still in operation, which occur in all parts of the globe, afford strong arguments in favor of the hypothesis of central heat.

And though we are at present unacquainted with the exact law of the increment of heat at different depths, and though, no doubt, under enormous pressure the temperature of the fusing-point of all substances may be considerably raised, yet the fact of the heat increasing with the depth from the surface seems so well established that it is highly probable that at a certain depth such a degree of heat must be attained as would reduce all min-

* Vol. v, p. 5.

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eral matter with which we are acquainted into a state of fusion. When once this point was attained, it seems probable that there would be no very great variation in the temperature of the internal mass; but whether the whole is in one uniform state of fluidity, or whether there is a mass of solid matter in the center of the fluid nucleus, are questions which do not affect the hypothesis about to be considered.

Those who are inclined to regard the earth as a solid or nearly solid mass throughout, consider that many volcanic phenomena may be accounted for on the chemical theory, which has received the support, among others, of Sir Charles Lyell. But apart from the consideration that such chemical action must of necessity be limited in its duration, the existence of local seas of fluid matter, resulting from the heat generated by intense chemical action, would hardly account for the increase of heat at great depths in places remote from volcanic centers; and the rapid transmission of shocks of earthquakes and the enormous amount of upheaval and subsidence as evidenced by the thickness of the sedimentary strata, seem inconsistent either with the general solidity of the globe or any very great thickness of its crust.

The supposition that the gradual oscillations of the surface of the earth, of which we have evidence all over the world as having taken place ever since the formation of the earliest known strata up to the present time, are due to the alternate inflation by gas and the subsequent depletion of certain vast bladdery cavities in the crust of the earth, can hardly be generally accepted.

Those who wish to see the arguments for and against the theory of there being a fluid nucleus within the earth's crust, will find them well and fairly stated in Naumann's 'Lehrbuch der Geognosie.'* My object is, not to discuss that question, but to point out what, assuming the theory to be true, would be some of the effects resulting from such a condition of things, more especially as affecting climatal changes. The agreement or disagreement between these hypothetical results and observed facts may ultimately assist in testing the truth of the assumption.

The simplest form in which we can conceive of the relations to each other of a solid crust and a fluid nucleus in rotation together is that of a sphere.

Let A C B D be a hollow sphere composed of solid materials and of perfectly uniform thickness and density, and let it be filled with the fluid matter E, over which the solid shell can freely move, and let the whole be in uniform rotation about an

* 2nd edit., 1858, vol. i, p. 36.

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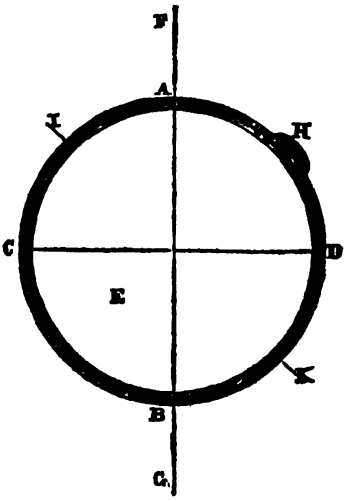
axis FG, the line CD representing the equator. It is evident that in such a case, the hollow sphere being in perfect equilibrium, its axis and that of its fluid contents would perpetually coincide. If, however, the equilibrium of the shell or crust be destroyed, as, for instance, by the addition of a mass of extraneous matter at H, midway between the pole and the equator, not only would the position of the axis of rotation be slightly affected by the alteration in the position of the center of gravity of the now irregular sphere, but the centrifugal force of the excess of matter at H would gradually draw over the shell toward D until, by sliding over the nucleus, it attained its greatest possible distance from the center of revolution by arriving at the equator. The resultant effect would be that though the whole sphere continued to revolve around an axis as nearly as possible in the line F G, yet the position of the pole of the hollow shell would have been changed by 45°, as by the passage of H to the equator the points I and K would have been brought to the poles by spirals constantly decreasing in diameter, while A and B, by spirals constantly increasing, would have at last come to describe circles midway between the poles and the equator.



The axis of rotation of the hollow sphere and that of its fluid contents would now again coincide, and would continue to do so perpetually unless some fresh disturbance in the equilibrium of the shell took place.

If instead of the addition of fresh matter at H we had supposed an excavation or removal of some portion of the shell, a movement in the axis of rotation of the shell would also have ensued, since from the diminished centrifugal force of that portion of the hollow sphere where the excavation had taken place, it would no longer equipoise the corresponding portion on the opposite side at I, and the excavated spot would eventually find its way to the pole.

In order more clearly to exhibit these effects, I have prepared a model in accordance with a suggestion of Mr. Francis Galton, F.R.S., in which a wheel representing a section of a hollow sphere has its axis, upon which it can freely turn, fixed in a frame, which is itself made to revolve in such a manner that the

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axis of its rotation passes through one of the diameters of the wheel, and coincides with what would be the axis of the sphere of which the wheel is a section.

In the periphery of the wheel are a number of adjustable screws with heavy heads, so that, by screwing any of them in or out, the addition of matter or its abstraction at any part of the sphere may be represented.

If by adjusting these screws the wheel could be brought into perfect equilibrium, its position upon its own axis would remain unchanged in whatever position it was originally placed, notwithstanding any amount of rotation being given to the frame in which it is hung; but practically it is found that with a certain given position of the screws a certain part of the wheel coincides with the axis of the frame, or becomes the pole around which the sphere revolves. The rim of the wheel is graduated so as to show the position of the poles in all cases, and generally speaking the wheel always settles down after rotation with the pole within three or four degrees of the same spot, if no alteration has been made in the adjustment of the screws, though of course what was the uppermost pole may become the lower one; and in some cases the wheel may be *in æquilibrio* with a projecting screw either above or below the equator, in which case there may be four readings on the circle at the index-point, according as the one pole or the other is uppermost, and the projecting screw is above or below the equator.

With the screws on the wheel evenly balanced, a slight alteration in the adjustment of any of them immediately tells upon the position of what, for convenience sake, may be called the poles, except, indeed, in such cases, as screwing outward those already at the equator, or making similar alterations in the adjustment of two screws at equal distances on either side of one of the poles. If a screw be turned outward so as notably to project at any spot, no matter how near to the pole, it will be found, after the machine has been a short time in revolution, in the region of the equator. Or again, if one or, better still, two opposite screws at the equator be turned inward, they will be found after a short period of revolution at the poles.

Now let us assume for a moment that, though the crust was partially covered by water, the earth, instead of being a spheroid, was a perfect sphere, consisting of a hardened crust of moderate thickness supported on a fluid nucleus over which the crust could travel freely in any direction, but both impressed with the same original rotatory motion, so that without some disturbing cause they would continue to revolve forever upon the same axis, and as if they were one homogeneous body. Let us assume, moreover, that this crust, though in perfect equilibrium on its center of rotation, was not evenly spherical externally,

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but had certain projecting portions, such as would be represented in nature by continents and islands rising above the level of the sea.

It is evident that so long as those continents and islands remained unaltered in their condition and extent, the relative position of the crust to the enclosed fluid nucleus would remain unaltered also. But supposing those projecting masses were either further upheaved from some internal cause, or worn down and ground away by the sea or by subaërial agency and deposited elsewhere, it seems impossible but that the same effects must ensue as we see resulting upon the model from the elevation and depression of certain screws, and that the axis of rotation of the crust of the sphere would be changed in consequence of its having assumed a fresh position on its fluid nucleus, though the axis of the whole sphere might have retained its original direction, or have altered from it only in the slightest degree.

An irregular accumulation of ice at one or both of the poles, such as supposed by M. Adhémar, would act in the same manner as an elevation of the land; and even assuming that the whole land had disappeared from above the surface of the sea, yet if by marine currents the shallower parts of the universal ocean were deepened and the deeper parts filled up, there would, owing to the different specific gravity of the transported soil and the displaced water, be a disturbance in the equilibrium of the crust, and a consequent change in the position of its axis of rotation.

Now if all this be true of a sphere, it will also, subject to certain modifications, be true of a spheroid so slightly oblate as our globe.

The main difference in the two cases is, that in a sphere the crust may assume any position upon the nucleus without any alteration in its structure, while in the case of the movement of a spheroidal crust over a similar spheroidal nucleus, every portion of its internal structure must be more or less disturbed as the curvature at each point will be slightly altered.

The extent of the resistance to an alteration of position arising from this cause will depend upon the oblateness of the spheroid and the thickness and rigidity of the crust; while the thicker the latter is, the less also will be the proportionate effect of such elevations, subsidences, and denudations as those with which we are acquainted. The question of friction upon the nucleus is also one that would have to be considered, as the internal matter though fluid might be viscous.

It will of course be borne in mind that the elevations and depressions of the surface of the globe are not, on the theory now under consideration, regarded according to the proportion they bear to the earth's radius, but according to their relation to the thickness of the earth's crust; and that, even assuming Mr. Hop-

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kins's extreme estimate to be true, yet elevations or depressions, such as we know to have taken place, of 8,000 or 10,000 feet, bear an appreciable ratio to the 800 or 1,000 miles which he assigns as the thickness of the earth's crust.

It is, however, to be remarked that the extremely ingenious speculations of Mr. Hopkins are based on the phenomena of precession and nutation, and that if once the possibility of a change in the position of the axis of rotation of the earth's crust be admitted, it is not improbable that the value of some of the data upon which the calculations of these movements are founded may be affected.

The supposition of the thickness of the crust being so great seems also not only entirely at variance with observed facts as to the increase of heat on descending beneath the surface of the earth, but to have been felt by Mr. Hopkins himself to offer such obstacles to any communication between the surface of the globe and its interior, that he has had recourse to an hypothesis of large spaces in the crust at no great depth from the surface, and filled with easily-fusible materials, in order to account for volcanic and other phenomena.

But though it may be possible to account for volcanoes upon such an assumption, yet, as already observed, the phenomena of elevation and depression, such as we find to have taken place, and more especially the existence of vast geological faults, cannot without enormous difficulty be reconciled with such a theory.

Taking the increment of heat as 1° Fahrenheit for every 55 or 60 feet* in descent, a temperature of 2400° Fahr. would be reached at about 25 miles, sufficient to keep in fusion such rocks as basalt, greenstone, and porphyry; and such a thickness appears much more consistent with the fluctuations in level, and the internal contortions and fractures of the crust which are everywhere to be observed. Sir William Armstrong, on the assumption of the temperature of subterranean fusion being 3000° Fahr., considers that the thickness of the film which separates us from the fiery ocean beneath would be about 34 miles.

Even assuming a thickness of 50 miles, so as to make still greater allowance for the increased difficulty of fusion under heavy pressure, the thickness of the crust would only form one-eightieth part of the radius of the earth; or if we represent the earth by a globe 18 feet in diameter, the crust would be one inch in thickness, while the difference between the polar and equatorial diameters would be half an inch.

In such a case, the elevation or wearing away of continents such as are at present in existence, rising, as some of them do, nearly a quarter of a mile on an average above the mean sea-

* Page, 'Advanced Text-book of Geology,' p. 30.

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level, would cause a great disturbance in the equilibrium of the crust, sufficient to overcome considerable resistance in its attempts to regain a state of equilibrium by a movement over its fluid nucleus.

Whether the thickness of the earth's crust was not in early geological times less than at present, so as to render it more susceptible of alterations in position—whether the spheroid of the fluid mineral nucleus corresponds in form with the spheroid of water which gives the general contour of the globe—whether or no there are elevations and depressions upon the nucleus corresponding to some extent with the configuration of the outer crust, and whether the motion of the crust upon it, besides effecting climatal changes, might not also lead to some elevations and depressions of the land, and produce some of the other phenomena mentioned by Sir Henry James, are questions which I will leave for others to discuss.

My object is simply to call attention to what appears to me the fact, that if, as there seems reason to suppose, our globe consists of a solid crust of no great thickness resting on a fluid nucleus, either with or without a solid central core, and if this crust, as there is abundant evidence to prove, is liable to great disturbances in its equilibrium, then it of necessity follows that changes take place in the position of the crust with regard to the nucleus, and an alteration in the position of the axis of rotation, so far as the surface of the earth is concerned, ensues.

Without in the slightest degree undervaluing other causes which may lead to climatal changes, I think that possibly we may have here a *vera causa* such as would account for extreme variations from a tropical to an arctic temperature at the same spot, in a simpler and more satisfactory manner than any other hypothesis.

The former existence of cold in what are now warm latitudes might, and probably did in part, arise from other causes than a change in the axis of rotation, but no other hypothesis can well account for the existence of traces of an almost tropical vegetation within the arctic circle.

Of the former existence of such a vegetation, the evidence, though strong, is not conclusive. But if the fossil plants of Melville Island, in lat. 75° N.,* which appear to agree generically with those from the English coal-measures, really grew upon the spot where they were now discovered, they seem to afford conclusive evidence of a change in the position of the pole since the period at which they grew, as such vegetation must be considered impossible in so high a latitude.

The corals and Orthoceratites from Griffiths Island and Cornwallis Island, and the Liassic Ammonites from Point Wilkie,

* Lyell, 'Principles of Geology,' 1853, p. 86.

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Prince Patrick's Island, tell the same story of the former existence of something like a subtropical climate at places at present well within the arctic circle.

To use the words of the Rev. Samuel Haughton,* in describing the fossils collected by Sir F. L. McClintock, "The discovery of such fossils *in situ*, in 76° N. latitude, is calculated to throw considerable doubt upon the theories of climate, which would account for all past changes of temperature by changes in the relative position of land and water on the earth's surface;" and I think that all geologists will agree with this remark, and feel that if the possibility of a change in the position of the axis of rotation of the crust of the earth were once admitted, it would smooth over many difficulties they now encounter.

That some such change is indeed taking place at the present moment may not unreasonably be inferred from the observations of the Astronomer Royal, who, in his Report to the Board of Visitors for 1861, makes use of the following language, though "only for the sake of embodying his description of the observed facts," as he refers the discrepancies noticed to "some peculiarity of the instrument. . . . . The transit circle and collimators still present those appearances of agreement between themselves and of change with respect to the stars which seem explicable only on one of two suppositions—that the ground itself shifts with respect to the general earth, or that the axis of rotation changes its position."

Art. XXVIII.—*On Fluorescence;* by J. Eneu Loughlin, Philadelphia.

In the year 1845, Sir J. Herschel published two papers in the 'Philosophical Transactions,' on what he termed the epipolic dispersion of light. His researches were made upon sulphate of quinia and other organic substances, from which researches he deduced the conclusion that the colors came from the surface of the liquid at which the light entered, and that a ray of light having once passed through such a stratum has lost the power of reproducing the same effect. Sir D. Brewster, in 1846, in a paper read before the Royal Society of Edinburgh, drew attention to a similar phenomenon in a solution of the green principle of leaves, and disproved the ideas of Sir J. Herschel, by showing that the light was dispersed not merely at the surface, but for a long distance within the fluid. In 1852, the subject was taken up by Mr. Stokes of Cambridge, and by him ably discussed. He examined many organic substances and arrived at

* Journal of the Royal Dublin Society, vol. i, p. 244.

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several valuable conclusions. He was the first to examine the fluorescent nature of glass colored by oxyd of uranium.

In June of the present year, I commenced a series of experiments upon the tinctures and infusions of the leaves, barks, and roots of various plants. A beam of sunlight was the agent employed for illumination. The apparatus, that of Prof. Stokes. Of the specimens examined, those worthy of note, with their results, are given in the following table:

Tinct. of	Quassia root,	light green.
"	Veratrum viride leaves,	greenish-yellow.
"	Aconite root,	orange-yellow.
"	Opium,	greenish-yellow.
"	Belladonna leaves,	yellowish-green.
"	Stramonium leaves,	light green.
"	Nux vomica root,	yellow.

The tinctures were then deprived of color by being filtered through animal charcoal, the object being to remove the coloring matter, as several of them gave reactions which were due to the presence of chlorophyll. On an examination they gave the following results:

Tinct. of	Quassia,	light green.
"	Veratrum viride,	yellowish-green.
"	Aconite,	yellowish-green.
"	Opium,	deep yellow tint.
"	Belladonna,	yellowish-green.
"	Stramonium,	light green.
"	Nux vomica,	light green.

Tinct. of Nux vomica deserves more than passing notice; when deprived of color it gave a faint green tint in place of the original yellow tint. All the alkaloids of the above that could be obtained were examined, viz:

Quassia,	distinct light green.	Codeia,	faint green passing to orange.
Veratria,	yellowish-green.	Atropia,	yellowish green.
Aconitia,	yellowish-green.	Strychnia,	faint green passing to orange.
Morphia,	yellow.		
Narcotina,	yellow.		

The next step was the examination of the fluorescence shown on the pouring of infusions of different substances into water contained in a tall jar, also the fluorescence shown by paper saturated with different infusions. The flame of burning sulphur served as the illuminating agent. The intensity of color varied as is shown in the table.

		Paper.	Liquid.
Infusion of	Esculin,	distinct,	distinct.
"	Cinchona,	pale,	distinct.
"	Quassia,	pale,	distinct.

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	Paper.	Liquid.
Infusion of Stramonium,	pale,	distinct.
" Aconite,	indistinct,	pale.
" Veratria,	indistinct,	pale.
" Galls,	distinct,	distinct.

For the light of sulphur was then substituted that of the following illuminating agents, alcohol flame colored by different substances being used, with the accompanying results.

Red by nitrate of strontia,	no action.
Green by nitrate of baryta,	indistinct.
Yellow by chlorid of sodium,	no action.
Violet by chlorid of potassium,	similar to sulphur.
Red by carbonate of lithia,	indistinct.
Blue by blue fire,	very distinct.
Potassium,	distinct.
Magnesium,	no action.

The infusions of the above were spread upon paper and made to receive the solar spectrum. Those that produced elongation of the violet portion were—

Infusion of Cinchona,	very decided.
" Esculin,	very decided.
" Quassia,	very distinct.

Philadelphia, Dec. 8th, 1866.

ART. XXIX.—*Note on Dr. Andrews' paper on the Glacial Drift;** by E. W. HILGARD, Prof. of Chemistry, University of Mississippi.

DR. ANDREWS' interesting paper on the Drift of Illinois, in the January number of this Journal, defines in a precise manner a point which I have heretofore failed to find distinctly elucidated, viz: the exact stratigraphical relations of the great stratified deposits of sand and gravel in the Northwest to such as exhibit unquestionable evidences of *glacier* action, and not only those which, so far as their character was concerned, might equally as well be referred to that of stranded floes, or shore-ice. It seemed strange, indeed, that the former should be absent, where so much of glacial transporting agency was apparent.

The occurrence of glacier-scored rocks is likely, in general, to be confined to a moderate distance from the parent glacier. Apart from the terminal moraine, we find them frozen into the bottom or sides of the glacier, and of course into the corresponding surfaces of the iceberg detached from it. They are therefore liberated by thawing long before those unscored an-

* This Jour., Jan. 1867, p. 75.

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gular blocks, which, by falling into crevasses, become enclosed in the mass of the glacier without penetrating to the bottom. It is only when two thick glaciers unite into one at a very acute angle, that scored rocks may become imbedded in the interior of the combined mass, and afterward be conveyed to considerable distances in an iceberg.

Stratification, therefore, must always be the criterion between the moraine and the deposits formed of the ballast dropped by floating ice, though, from the mode of formation, distinct or continuous stratification could not be expected even in the latter.

Dr. Andrews specially mentions the stratification of the drift penetrated in the Chicago tunnel, and that by great care it can be observed in the greater part of the formation. The latter is therefore clearly not of the moraine character—it is the result of the combined action of water and floating ice, as required by the hypothesis advanced in the paper referred to by him. Nor does the occurrence of the true "glacial drift" beneath the stratified beds in any way detract from the importance of the latter, and the necessity of assigning the origin of their "thick masses" to a cause more powerful in degree and more widely active, than is implied in the sentence quoted from Dana's Manual.

While angular blocks do occur in the stratified drift of middle Illinois and Missouri, they, nevertheless, manifestly decrease in proportion to those of rounded form, as we advance southward; and the lithological composition of the "Orange Sand" of the Southwest is precisely such as we should expect to result from the modification, in proportion to distance and lower latitude, of the agencies to which the stratified drift of the Northwest seems to owe its conformation.

University of Mississippi, Feb. 2, 1867.

Art. XXX.—*On Naphtha and Illuminating Oil from Heavy California Tar (Maltha)*; by B. Silliman.

Having lately had an opportunity to examine a specimen of "surface oil," so called, from Santa Barbara county, in California, I present the following experimental results in the hope that they may not be without interest, as an addition to our knowledge of one extreme of that class of hydrocarbons which occur in nature in the fluid form, and of every density, from those which are but little lighter than water down to the lightest naphtha found in a natural state.

It is proper to state that the chemical examination of this sample had chiefly a technical object, to prove whether or not illuminating oil of good quality could be obtained from the dis-

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tillation of so dense a body. The experiments were conducted on quantities of from five to ten gallons each. The crude oil was very dark, almost black, transmitting yellow brown light in thin films. At ordinary temperatures (60° F.) it is a thick, viscid liquid, resembling coal tar, but with only a very slight odor.

Its density at 60° F. is 0·980 or 13° Baumé. It retains, mechanically entangled, a considerable quantity of water, which is neutral in its reaction. The odor of sulphydric acid, which is very decided in this product, as I have noted in its locality, had entirely disappeared in the specimen under consideration.

The tar froths at the commencement of distillation, from escape of watery vapor. It yields by a primary distillation no product having a less density than 0·844, or 37° B. at 52° F.

Distillation to dryness produced in two trials an average result as follows:

Oil having a density of ·890 to 0·900, - -	69·82
Coke, water, and loss, - - - - - -	30·18
	100·00

In one of these trials the product was divided as follows:

Oil, of density 29° B. at 52° (·885 sp. gr.), -	50·0
" " 24·75 " 53° (·908 "), -	17·5
Coke, water, loss, &c., - - - - - -	32·5
	100·0

The coke is very large in quantity, strong, and is a good fuel, resembling gas-house coke. The odor of ammonia is given off toward the close of the distillation.

It is well known to distillers of petroleum that by the process called "cracking," heavy oils unfit for illumination are broken up into bodies of less density, from light naphtha to the heavier illuminating and lubricating oils. This process is simply the application of a carefully regulated heat producing a slow distillation. By this treatment the molecules apparently rearrange themselves into groups of different density, which by a subsequent distillation are divided into fractions (or "heaps" as Mr. Warren calls them) of tolerably constant boiling points.

The first distillate, having a density of about ·890 at 60° F., treated in this manner, yielded a product having a density of about ·885 at 60°, or only 1° Baumé lower than before distillation. After treatment with sulphuric acid and soda and redistilling from soda, it had a density of ·880 at 60° F. Upon redistilling, 100 measures of this last distillate yielded—

Light oil having a density of about ·834 at 60° F.,	21·58
Heavy " " " " ·880 " 66° F.,	37·41
" " " " " ·916 " 64° F.,	34·53
Coke, &c., - - - - - - - - -	6·48
	100·00

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In another experiment undertaken with a view to "cracking," &c., treating and redistilling with soda, the products were as follows, stated in percentages of the whole quantity operated on, the several steps being as before.

Naphtha,*	sp. gr. about ·760 at 60° F., - -	11·33
Oil,†	" " ·836 " " - -	66·22
"	" " ·893 " " - -	12·67
"	" " ·921, - - -	3·56
Loss, - - - - - - - -		6·22
		100·00

The illuminating oil from both these experiments, after treatment with sulphuric acid and soda in the usual manner, acquired an agreeable odor, a light straw-yellow color, and burned as well in a lamp as good commercial oil.

With a view to test the effect of heat aided by pressure in breaking up the heavy hydrocarbons—a method of treating heavy hydrocarbon oils patented in 1866 by Mr. James Young of Glasgow—a portion of the first distillate from the crude oil was subjected during distillation to a pressure of ten to fifteen pounds to the square inch, in an apparatus adapted to the purpose, the distillate thus obtained being about the same density as in the first named experiment, ·890 at 60° F.

From this distillate were obtained, after the ordinary treatment with sulphuric acid and soda, the following products:

Light oil,	sp. gr. ·825 at 60° F., - -	19·2 p. c.
Heavy "	" ·885 " " - -	25·86 "
" "	" ·918 " " - -	38·14 "
Coke, loss, &c.,	- - - - -	16·80 "
		100·00

The illuminating oil from the last experiment flashed at 80° F. and lighted on the surface at 85° F., showing the presence of naphtha or some very light body, the quantity of which cannot be very considerable. The light oil could with care be taken off in practice without materially diminishing the yield of illuminating oil. It would be rash to conclude that there may not be an important economical advantage in employing in the large way Mr. Young's method of treatment under pressure, over that of "cracking" by a regulated heat alone. It is highly probable that there would be found an important saving of time, as under a regulated pressure and a corresponding increase of temperature, the transformation of the heavy oils into a mixture of those of less density, will occur more speedily. The experiments herein mentioned gave nearly the same result whether

* This naphtha caught fire from a match at an atmospheric temperature of 56° F.
† This oil flashed at 113° F. and ignited at 124° F.

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pressure was used or not; a certain loss, all falling upon the lighter portions, was found to result from leakage of the apparatus under pressure, which in the larger way of operating commercially could be avoided.

No paraffine could be detected by refrigerating the heavy oils obtained in these distillations in a mixture of salt and ice. It is no doubt the absence of this body from the series of products obtained from the California oils generally, that accounts for the illuminating oil burning well at a density considerably below the commercial standard for oil obtained from Pennsylvania petroleum—a difference enhanced also by the absence of any considerable quantity of light naphtha. The lubricating oils of this series, likewise free from paraffine, retain on this account their fluidity at low temperatures.

The light oils obtained in this series of experiments correspond respectively to 12·96, 14·56 and 18·96 per centum of the crude oil. The total commercial products are about 60 per cent of the crude body, which likewise yields sufficient coke to supply the fuel required in the distillations.

In the large way, by returning the lightest oils to the heavier portions in the successive distillations and employing Mr. Young's method by pressure, it is probable the product of light or illuminating oils may be raised in these very heavy natural products to 80 per cent.

It is evident from these experiments that heavy hydrocarbon oils containing no naphtha are convertible into oils of the naphtha series under the action of heat by molecular transformations, the excess of carbon being left behind as coke; each successive distillation eliminating a new but always a diminished portion of carbon.

I am indebted to Mr. A. J. Corning, formerly assistant to Mr. Warren, for conducting this research under my direction; and to Messrs. Downer and Merrill, of the kerosene works in South Boston, I am under many obligations for the permission to employ their operative laboratory in conducting this research. As before stated, the research had chiefly a technical object, the points of scientific interest being subordinate in a great degree. For the crude material operated on I am indebted to the California Petroleum Company, from whose estate it was derived.

Note.—In the number of this Journal for May, 1865, I published the analyses of a sample of crude petroleum, believed by me to be from a well-known spring, called the "Pico Spring," in Santa Barbara county, California. This sample, as well as a subsequent one in larger quantity, came to me under seal from responsible parties and no question of its authenticity, until a very recent period, ever reached me. It is now confidently asserted,

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by certain parties, that the samples in question were sophisticated by the addition of refined commercial petroleum. An inquiry instituted privately by me has elicited from the parties immediately concerned in its transmission only an emphatic denial of the charge of falsification, and if any such fraud has been perpetrated I am well persuaded that the responsibility falls elsewhere. My investigations in this direction are unrelaxed, and the truth cannot remain long concealed.

New Haven, January 14th, 1867.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the influence of the absorption of heat upon the formation of dew.*—The long pending controversy between Magnus and Tyndall in relation to the absorptive power of aqueous vapor, appears to have been brought to a conclusion by an experiment of Magnus based upon the principle of the equality of the radiating and absorbing powers of bodies. The apparatus employed consisted of a horizontal brass tube, which could be heated red hot by means of a row of burners, and served to conduct the gases and vapors to be examined. One end of this tube was turned up vertically so as to form the radiating jet of gas or vapor; the other was connected with a bellows, while by means of interposed branched tubes and other apparatus the air driven through could be previously dried or passed through water at a known temperature: finally, pure aqueous vapor could be employed to form a jet without admixture of air. A thermometer was suspended over the jet so that its temperature could be determined with sufficient accuracy. The heat radiated from the jet of gas or vapor was allowed to fall upon one surface of a thermo-pile provided with conical reflectors and placed within a double chest of card-board. The effect produced by the radiation of heat from other sources than the jet of gas or vapor was compensated by placing a second and precisely equal source of heat upon the other side of the thermo-pile. With this arrangement a jet of dry air produced by radiation a deviation of the galvanometer which amounted to only three divisions of the scale. When the air was passed through water the deviation remained almost the same. When dry carbonic acid gas was passed through the hot brass tube the deviation amounted to 100–120 divisions, and common illuminating gas gave nearly the same deviation. When air was passed through water heated to 60°–80° C. the deviation rose to 20, but very gradually, while the deviations produced by carbonic acid and illuminating gas were sudden, and rapidly rose to their maxima. When the water boiled so as to produce clouds in the jet of air the deviation exceeded 100 scale divisions, and the same result took place when no jet of air was forced through but the steam alone formed vesicular vapor. When no vesicular vapor was present the galvanometer gave no greater deviation than 20, no matter how much steam might be present.

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The greater deviation invariably accompanied the formation of vesicular vapor. From these experiments Magnus concludes that transparent or proper aqueous vapor has a radiating and absorbing power but little greater than that of air, and consequently that the absorptive power of air which contains transparent vapor differs but little from that of dry air. In conclusion the author brings forward an argument based upon the formation of dew. If aqueous vapor were as good an absorbent of heat as Tyndall supposes, dew could never be formed at all, since the vapor necessary for its formation would form a covering over the surface of the earth and prevent radiation. In the tropics, where the atmosphere is loaded with moisture, the dew is very heavy. If the vapor of water possessed as high an absorptive power as Tyndall attributes to it, only a small portion of the heat radiated from the earth could reach the clouds, and the effect of clouds in preventing the formation of dew could not be explained. The conclusions of Frankland in regard to the ice period, and of Tyndall for certain climatic phenomena, based upon the absorptive power of aqueous vapor, remain unchanged if we substitute vesicular vapor. The author further cites the experiments of Cooke and Secchi in regard to the absorption of light by aqueous vapor as shown by the spectroscope, a few dark lines being produced which scarcely diminish the total intensity of the light.—*Pogg. Ann.*, cxxvii, 613.

W. G.

2. *On some new forms of electrical apparatus.*—TÖPLER and HOLTZ have described independently, but at about the same time, new forms of electrical machines which may be regarded most simply as rotating electrophori. Töpler's machine, which is the simpler of the two, consists essentially of a circular plate or disc of thin vulcanized rubber, gutta percha or glass, mounted upon a vertical axis and caused to rotate rapidly by means of a band and wheel. The disc is coated upon each side with two segments of tin foil, a free space being left between the segments, while the coatings are connected over the edge of the disc by strips of foil. A piece of hard rubber forming a segment of a circle is then excited by friction and placed near and parallel to the lower coated surfaces of the revolving disc. This lower surface becomes electrical by induction, the opposite electricity being driven over the edge to the upper surface of the plate. As the plate revolves, one under segment of tin foil is removed from the inductive action of the excited surface, and the second becomes parallel to it, when the free electricity is decomposed as before. Two isolated conductors are placed above and parallel to the disc, and each carries at one end a light spring or strip of tin foil which rests upon the upper surface of the disc. The two strips are so arranged that as the disc revolves one strip is just leaving a segment of tin foil as the other is brought into contact with it. In this manner the electricity driven to the upper surface is first carried off by one conductor, while the electricity retained upon the lower surface at first, as the plate revolves, passes to the upper surface and is drawn off by the second conductor. The same process then takes place with the second coating, and so on alternately. It will be seen that so far the apparatus is exactly equivalent to an electrophorus, and that the action, though powerful at first, must diminish rapidly as the inductor loses electricity. To remedy this

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difficulty a second but smaller disc of glass is placed on the same axis, coated with tin foil in the same manner and provided with a similar inductor and similar conductors. This second inductor is connected with one pole or conductor of the upper and larger plate. Of the two similar conductors belonging to the lower plate, one is connected with the earth while the other is connected with the inductor of the upper plate. In this manner, as the discs rotate, the earth furnishes a constant supply of electricity, and the action of the machine is remarkably powerful. Holtz's machine depends upon similar principles, but could hardly be made intelligible without figures. Several of them have already arrived in this country. A simpler form of apparatus of the same kind has since been described by Bertzch. All these instruments appear to be very much more powerful than plate electrical machines of the same size, and they have the advantage of working with but a small application of force.—*Pogg. Ann.*, cxxv, 469; also Holtz in *Pogg. Ann.*, cxxvii, 320; Bertzch in *Cosmos*, No. 7, 1866. W. G.

3. *On nitrites of cobalt and nickel.*—O. L. Erdmann has described a series of double nitrites which, while not wanting in interest from a theoretical point of view, are of some importance in analytical chemistry. Nickel gives, with potash and nitrous acid, a soluble double salt, crystallizing in brownish-red octahedrons and having the formula $2KO,NO_3+NiO.NO_3$, as already found by Lang and Rammelsberg. When a solution of this salt is mixed with one of chlorid of calcium, or when nitrite of potash is added to a solution containing both nickel and calcium, a yellow crystalline precipitate is formed which is very slightly soluble in cold but much more soluble in hot water. The solution is green, but the salt is always more or less decomposed. When the salt is formed slowly it crystallizes in well-defined regular octahedrons. Its constitution is represented by the formula

$$CaO,NO_3+NiO.NO_3+KO,NO_3 \text{ or } \left.\begin{matrix}NiO\\CaO\\KO\end{matrix}\right\}3NO_3.$$

The corresponding barium salt has been described by Lang. It is also very slightly soluble in water, and crystallizes in microscopic cubes with octahedral faces. The strontium salt forms reddish-yellow crusts consisting of microscopic cubes. Cobalt forms precisely analogous compounds. The triple nitrite of cobalt, potash and lime, forms a black-green crystalline precipitate. The salts of cobalt with barium and strontium, have a still more beautiful green color, but like the calcium salt are decomposed by washing. The ammonia nitrite of nickel, which Erdmann terms nitrite of diamin-nickel, forms small cherry-red brilliant crystals having the formula $2NH_3.NiO,NO_3$, and easily decomposed. Fischer's nitrite of cobalt and potash, which according to Stromeyer has the formula $Co_2O_3.2NO_3+3KO,NO_3$, is, according to Erdmann, a mixture of two different salts, one of which is formed in an acid and the other in a neutral solution. The salt formed in a neutral solution has the formula $\left.\begin{matrix}3CoO\\3KO\end{matrix}\right\}6NO_3+HO$. It is a yellow crystalline powder composed of microscopic cubes. The author has satisfied himself that no absorption of oxygen takes place during the formation of this salt,

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and consequently that the cobalt is present as protoxyd, and not as sesquioxyd as Stromeyer supposed. The salt is insoluble in cold water, but dissolves in boiling water with a red color. When a solution of chlorid of cobalt is acidulated with acetic acid and then a solution of nitrite of potash added, a yellow precipitate of a brighter color than that of the last mentioned salt is formed. If the quantity of acetic acid is small the solution gradually becomes less acid and finally weakly alkaline. The first mentioned salt is then deposited, so that in analyses the substance weighed is usually a mixture of the two salts. The salt precipitated from an acid solution has the formula $\left.\begin{matrix}2CoO\\3KO\end{matrix}\right\}6NO_3+3HO$, which may perhaps be written more correctly $\left.\begin{matrix}2CoO\\3KO\\HO\end{matrix}\right\}6NO_3+2\text{ aq}$. The corresponding ammonia salt has the formula $\left.\begin{matrix}2CoO\\3NH_4O\\HO\end{matrix}\right\}6NO_3+2\text{aq}$, and consists of microscopic cubes slightly soluble in cold water with a yellow color. When a solution of chlorid of cobalt is heated with much sal-ammoniac, and then with a solution of nitrite of potash, a yellow precipitate is formed in brilliant micaceous scales, while the liquid becomes strongly acid and evolves nitrous acid. The mother liquor afterward deposits brown crystals. The yellow salt appears not to have a constant composition, but the brown compound is easily purified by recrystallization; it has the formula $2NH_3.Co_2O_3, 3NO_3+KO, NO_3$. With nitrate of silver this salt gives a yellow or orange precipitate which has the formula, $2NH_3.Co_2O_3, 3NO_3+AgO, NO_3$. The author describes a corresponding ammonium salt isomorphous with the potassium compound. When a solution of chlorid of cobalt is heated with an excess of a mixture of ammonia and nitrite of potash, the solution absorbs oxygen on standing and becomes darker, depositing finally bright brownish-yellow leaf-like crystals which are with difficulty soluble in cold water but dissolve pretty easily in hot water, and crystallize from the solution in the form of brilliant deep yellow flat needles or leaves. This compound has the formula $3NH_3.Co_2O_3, 3NO_3$, and appears to be the nitrite of the base $3NH_3.Co_2O_3$, the sulphite of which was described by Künzel.—*Journal für prakt. Chemie*, xcvii, 385. W. G.

4. *On the synthesis of alcohols by means of chlorinated ethers.*—Lieben has studied the action of zinc-ethyl upon the chlorinated ethers, and has obtained results of great interest closely connected with those of Frankland on the structure of the organic acids. By the action of zinc-ethyl upon bichlor-ether, $\left.\begin{matrix}C_2H_3Cl_2\\C_2H_5\end{matrix}\right\}O$, Lieben and Bauer had already obtained ethylo-chlor-ether, $\left.\begin{matrix}C_2H_3.Cl.C_2H_5\\C_2H_5\end{matrix}\right\}O$. By the action of concentrated iodhydric acid upon this body the chlorine is in a great measure replaced by hydrogen, iodine is set free and a heavy oil is formed containing iodid of ethyl, ethylated chlor-ethyl, and ethylated iodid of ethyl. Ethylated iodid of ethyl has the constitution and boiling point of Wurtz's iodid of butyl. With acetate of silver it yields ethylated

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acetate of ethyl and butylene. Ethylated acetate of ethyl, by boiling with concentrated caustic potash yields ethylated alcohol, which has the properties of the butyl-alcohol obtained by Wurtz from the fusel oil of beet sugar. Lieben thinks it probable, however, that this body is only isomeric with butyl-alcohol and is identical with butylene-hydrate. By the action of iodhydric acid upon biethylated ether, $\left.\begin{matrix}\text{Є}_2\text{H}_3 . \text{Є}_2\text{H}_5 . \text{Є}_2\text{H}_5 \\ \text{Є}_2\text{H}_5\end{matrix}\right\} \Theta$, Lieben has obtained biethylated iodid of ethyl, from which it is probable that biethylated ethyl-alcohol will be obtained. This would be a secondary or tertiary alcohol isomeric with normal butyl alcohol. The author promises a continuation of these researches which can hardly fail to result in the formation of a great number of new alcohols with their corresponding acids.—*Sitzungsber. der Wiener Acad.*, liv, 225, quoted in *Chem. Centralblatt*, No. 1, 1867. W. G.

5. *Graphitoidal Boron, a compound of aluminum.*—St. Claire Deville communicated to the French Academy at its session on the 21st of January the fact that in connection with Wöhler he had recently ascertained that the variety of boron called graphitoidal, originally described by them, was not pure boron, but a definite compound of boron with aluminum. It is formed in the preparation of crystallized boron by means of aluminum, especially when the temperature is not sufficiently high. This aluminic borid crystallizes in very fine hexagonal plates, of the color of pale copper, is perfectly opaque and possesses a metallic luster. According to W. H. Miller these plates belong to the monoclinic system. Heated in the air, it does not burn, but is blued like steel. In chlorine it burns forming aluminic and boric chlorids. It is slowly soluble in hot concentrated chlorhydric acid, and in a hot solution of sodic hydrate, evolving hydrogen. In very strong nitric acid it dissolves easily. The addition of ammonic carbonate to this solution precipitates a basic aluminic borate. In the analysis the boric acid was expelled from this precipitate by fluohydric acid, and then the fluorine by sulphuric acid. Two analyses gave 54·02 and 54·91 per cent respectively of aluminum, corresponding to the formula AlB_2.—*L'Institute*, 1867, p. 27.

6. *Tests for glucose.*—Braun uses a solution of picric acid in 250 parts of water. The glucose solution, containing a little caustic soda, is heated to 90°, a few drops of the picric solution are added, and the whole raised to ebullition; the presence of glucose is indicated by a blood-red coloration due to the production of picramic acid. Cane sugar does not produce this change.—*J. pr. Ch.*, xcvi, 411.

Franqui and deVyvere modify Böttger's test by using an alkaline solution of the bismuthic oxyd. It is prepared by precipitating bismuthic nitrate by a large excess of potash, and adding gradually to the mixture, moderately heated, a solution of tartaric acid; the precipitate dissolves completely, even before the liquid becomes neutral. If a few drops of this reagent be added to diabetic urine, and the whole be boiled, the liquid speedily becomes black and throws down a deposit of metallic bismuth.—*Jour. Med. Brux.*, 1865, 359.

7. *Hydrocarbons from animal fats.*—Warren and Storer have examined the products resulting from the destructive distillation of a lime soap, produced by the saponification of "menhaden oil," from the *Alosa*

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menhaden. The crude hydrocarbons thus obtained were distilled in a current of steam, the distillate treated with sulphuric acid and soda, and again distilled. The rectified product "so closely resembled refined coal oil and petroleum in odor, color, and illuminating properties, that it could hardly be distinguished from these." Their special investigation, however, was confined to the naphtha obtained from the crude product by Warren's process of fractional condensation; indicating by this name, all those hydrocarbons which passed the hot condenser at 220° C. By repeated distillations of this sort, occupying nearly a year, sixteen bodies of constant boiling point were obtained, belonging to several series. To the hydrid series (C_nH_{2n+2}) the hydrids of amyl, caproyl, œnanthyl and capryl; to ethylene series (C_nH_{2n}) amylene, caproylene, œnanthylene, caprylene, pelargonene, rutylene, margarylene, laurylene; and to the benzole series (C_nH_{2n-6}) benzole, toluole, xylole, isocumole. 23·5 per cent consisted of isocumole and rutylene; 13·3 per cent of xylole; 12·5 per cent of caprylene and hydrid of capryl; and 10·2 per cent of margarylene. The importance of this research in relation to the geological production of petroleum is at once evident.—*Mem. Am. Acad.*, new series, ix, 177.

8. *Naphtha from Rangoon petroleum.*—Warren and Storer communicate also the result of the examination, by fractional condensation, of the naphtha from Rangoon petroleum. Owing to the limited supply of material in their hands, they regard their results as only partially complete. Of the hydrid series they assume the presence in this naphtha of the hydrids of œnanthyl, capryl, and pelargonyl; of the ethylene series, they obtained rutylene, margarylene, laurylene, cocinylene, and probably pelargonene; and of the benzole series they regard the presence of xylole and isocumole as probable.—*Mem. Am. Acad.*, new series, ix, 208.

9. *Synthesis of petroleum.*—Berthelot has recently raised the question whether the hydrocarbons found so abundantly in many places may not be of inorganic origin. How otherwise can their presence in volcanic vapors and even in meteorites be accounted for? Without presuming to decide the matter, he thinks it of interest to show, from his recent researches, how such compounds could be formed from purely inorganic materials. If we admit that the alkaline metals may exist in the earth's interior, a hypothesis by no means improbable, the production of these hydrocarbons necessarily follows. For by the action of these alkaline metals upon carbonates, Berthelot has shown that acetylids result; as for example from calcic carbonate, is produced calcic acetylid ($\mathrm{C}_2\mathrm{Ca}$). By the action of water upon these compounds free acetylene is evolved; thus $\mathrm{C}_2\mathrm{Ca}+(H_2O)_2=\mathrm{C}_2H_2+\mathrm{Ca}H_2O_2$: but under the conditions of pressure and temperature there existing, the acetylene would at once be condensed, forming the benzole series; $(\mathrm{C}_2H_2)_3=\mathrm{C}_6H_6$ or benzole. But from the action of steam upon the alkaline metals, hydrogen would be evolved; and this hydrogen, being condensed with the acetylene, would produce the ethylene series ($\mathrm{C}_2H_2+H_2=\mathrm{C}_2H_4$); or even the hydrid series ($\mathrm{C}_2H_2+H_4=\mathrm{C}_2H_6$ ethylic hydrid), all of which series occur in natural hydrocarbons. "We can thus conceive the production by a purely mineral method of all the natural hydrocarbons. The intervention of heat, water, and alkaline metals,—lastly the tendency of the carbides to unite together so as to form matters more condensed, suffice

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to account for the formation of these curious compounds. This formation can also be effected in a continuous manner since the reactions which produce it are incessantly renewed."—*Ann. Ch. Phys.*, December, 1866.

10. *Silvering upon glass.*—Having occasion recently to silver some thin microscopic glass, several processes were tried with indifferent success, until finally I hit upon Bothe's method as modified by Böttger (J. pr. Ch., xcii, 494) which afforded most excellent results. Its simplicity, economy, and satisfactory performance induce me to reproduce it here.

7·8 grams of argentic nitrate are dissolved in 60 cc. of water and the solution is divided into two equal portions. A solution of 3·11 grams potassio-sodic tartrate (Rochelle salt) in 1420 cc. of water being brought to *active ebullition*, one of the above portions of the silver solution is gradually added, the boiling is continued 8 or 10 minutes, the whole is allowed to cool and is then filtered. This is the reducing solution.

To the second portion of the silver solution, caustic ammonia is added till the precipitate is *almost* redissolved, care being taken to avoid an excess, and then 355 cc. of water being added, the whole is filtered.

To silver the glass, equal portions of these two fluids, thoroughly mixed and perfectly clear, are poured upon it. After the lapse of about *ten minutes*, a most brilliant layer of metallic silver is deposited, which may be thickened to any desired extent by repeating the process. The film is protected by a layer of varnish. G. F. B.

11. *Nodal figures in organ pipes;* by Dr. August Kundt.—In continuing his acoustic researches (see this Journal, Sept., 1866,) Dr. Kundt has made some farther very interesting discoveries, which are of great theoretical importance and very useful in the lecture room. First he substitutes fine ground or precipitated silicic acid in the place of lycopodium: the silica can be freed from all moisture by ignition, is not acted upon by gases, is equally light, etc. Repeating the experiment reported in the September number of this Journal, he discovered that the *silica forms very thin vertical partitions often across the whole section of the tube while vibrating*, dropping down at the close of the motion, thus forming the transverse ripplings there spoken of.

Taking now an organ pipe—say the mouth-piece of a common tin whistle to which a clean dry glass tube is attached by means of a rubber tube—and intonating any of the higher tones of the pipe, and, if necessary, aiding the silica evenly distributed in the horizontal tube by a few light taps to follow the undulations of the air,—we see a nodal figure of great beauty and distinctness appear, most readily in a closed, but also in an open, pipe. The whole pipe is divided into oval nodal spaces, distant half a wave-length from one another, and between them we see fine, parallel and very distinct, nearly equidistant transverse ripplings, resulting from the transverse walls raised in the tube during the vibration. The experiment is so easily repeated (blowing by means of a bellows or even the mouth) and the nodal figures so exceeding beautiful both during and after the intonation, and the same may so easily be preserved thereafter, that every reader ought to repeat the experiment. Measuring the distance of any two nodal areas gives with great accuracy the half-wave-length of the tone; the same pipe may in quick succession—after

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merely shaking up the silica in the pipe—be made to give different tones, the pitch of which is easily ascertained by the ear, and the length of whose waves is found to coincide admirably with the calculation based upon the first determination and the interval—or the velocity of sound and the number of vibrations. The known methods of Hopkins, König, and others, for representing the vibrations of the air in organ pipes are very deficient: Kundt's method is as complete as it is simple.

But it shows more than anticipated. If repeated by means of a vertical pipe, with a *gas-flame* in place of the silica, this flame shows a corresponding stratification in dark and bright layers—the luminous strata evidently due to an accumulation of carbon particles. The mutual distance of these luminous strata is nearly proportional to the length of the tube. From this and other facts Dr. Kundt concludes that the rippling of the silica and the stratification of the flame probably are due to the higher or *secondary tones* (obertöne of Helmholtz) coëxisting with the one produced, and whose wave-length is measured by twice the distance between two consecutive nodal areas.

For farther detail, and many other interesting results, we must refer to the paper of Kundt in Poggendorff's Annalen, 1866, cxxviii, 337–355 and 496. In the same volume, page 610–613, the same investigator gives an interesting method for the observation of the vibratory forms of plates by means of reflection. G. H.

12. *Influence of the interior friction of the air on the transmission of sound;* STEFAN (Acad. Vienna, April, 1866).—The analytical results are:

(1.) The velocity is greater for the tones of higher pitch; for the highest tones it only is one-thousandth of a millimeter [so that dispersion of sound is practically impossible?].

(2.) The amplitudes of plane progressive waves decrease in a geometrical progression, the ratio of which is proportional to the square of the number of vibrations. The amplitude is reduced to one-ninth in 1000 meters for 10,000 vibrations, or in 100 meters for 30,000 vibrations per second.

(3.) In stable vibrations the wave-length cannot be greater than four times the mean excursion of a molecule of the air (as assumed in Krönig's theory of the construction of gases).

(4.) The amplitudes in stable waves decrease in geometrical progression of the time, the ratio being proportional to the square of the number of vibrations. Thus the amplitudes of tones of 1000, 10,000, and 30,000 vibrations will in 100, 1, and $\frac{1}{10}$ second be reduced to one-half their original amount.—*L'Institut*, 1866, p. 271. G. H.

13. *Interferential tones.*—In May, 1866, STEFAN communicated to the Academy of Vienna some interesting experiments, giving for tones, the vibratory motion of which cannot be contested, a transformation perfectly analogous to the theoretical decomposition of light-waves traversing a quartz crystal in the direction of the axes and producing the rotation of the plane of polarization.

A square plate exhibiting two nodal lines at right angles will produce a more intense tone if the two opposite sectors (having the *same* motion) are covered with a card of their own figure and size: for then the parts

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of the plate adjacent to these will alone move the air with concordant impulses. If now the card (or the plate) be rotated n' times a second, the intensity will show n' periods per second; if the amplitude of the original vibration of the plate be a, the amplitude corresponding to the rotation of the card be a', and the pitch of the tone of the plate n, we have $a=a'\sin 2n'\pi t$, and hence the original tone $A=a\sin 2n\pi t$ becomes

$$A=a'\sin 2n'\pi t\sin 2n\pi t=\frac{a'}{2}\cos 2(n-n')\pi t-\frac{a}{2}\cos 2(n+n')\pi t,$$

that is *two tones of pitch* $n-n'$ *and* $n+n'$ (or a *graver* and a *higher* tone) *will be heard instead of the primary tone of pitch* n.

Thus Stefan found that a plate giving the tone fis_2, which according to Quincke's table (this Journal, Nov. 1866, p. 417) corresponds to $185=n$ vibrations, produces, when $n'=10$ rotations per second, the tones $f_2=174{\cdot}6$ and $g_2=196$, which are very nearly 185 ± 10. L'Institut gives fis_1, etc., no doubt by a mistake in translating Stefan's German notation.—*L'Institut*, 1866, No. 1710, p. 327; *Cosmos*, 1866, vol. iv, pp. 458, 459. G. H.

14. *Foucault's silvered objectives for observations of the sun.*—A very ingenious method for close observation of the solar disc was communicated by Foucault in September, 1866. Having noticed that no heat and very little light is transmitted through the thin bright silvering of his glasses, he coated the outer surface of the objective of a refracting telescope with such silvering, and found, as he expected, that all heat-rays were reflected, as also the greater part of the light, so as to permit only a pale bluish-violet to pass through. LeVerrier reported, October, 1866, most favorably as to the results obtained by a 9-inch refractor (equatorial). No heat could be felt in the very focus of the objective directed toward the sun—thus freeing all solar observations of a very great cause of error. Furthermore only the ultra-red rays are really absorbed; all others are, as the prismatic spectrum shows, only diminished in intensity so as to give a steady (calme) and pure image of the sun, showing all detail of outline and color with excellent definition, and permitting a magnifying power of 300.—*L'Institut*, 1866, pp. 281, 313; *Cosmos*, 1866, iv, 387, 430. G. H.

15. *Lead-thallium glass* has greater density and refracting power than common lead-flint glass; 300 pure sand, 200 minium, and 335 carbonate of thallium (instead of the usual 100 carbonate of potassa), give a glass of density 4·235, index of refraction 1·71, and only very slight yellowish tint. It has been made in England.—*L'Institut*, 1866, p. 320. G. H.

16. *Expansion of water and mercury;* A. Matthiessen.—The results of this very elaborate investigation are—the volume of water at any temperature $t°$ C. is $V=a-bt+ct^2-dt^3$, the volume at 4° C. being 1 and the coëfficients

	for $4°<t<32$	for $32<t°<100°$
a	1·00018845328	0·999695
b	0·00000579896	0·000000
c	0·00000752824	0·00000054724
d	0·00000007173	0·000000011260

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The coëfficient of expansion for a volume of mercury he finds from five series of determinations (per degree C.)

0·0001812
Regnault found 0·0001815.

—*Poggendorff's Annalen*, 1866, cxxviii, 512–540. G. H.

17. *On the expansion of crystals.*—Fizeau has invented a method for the exact determination of the coëfficient of expansion of small solids (only a few millimeters thick), and obtained important results thereby (Cosmos, 1865, xxvi, 641). The following is the substance of a later and more elaborate research of Fizeau.

Let the coëfficient of expansion in the direction of the three axes of elasticity of any crystal be represented by α, α', α'', then the expansion D in any direction determined by the three angles δ, δ', δ'', will be

$$D = \alpha \cos^2 \delta + \alpha' \cos^2 \delta' + \alpha'' \cos^2 \delta'',$$

and the cubical expansion is

$$c = \alpha + \alpha' + \alpha'',$$

which is the same as D for $\delta = \delta' = \delta'' = 54° 41'$, or in a direction at right angles to the surface of a regular octahedron whose axes coincide with the directions of α, α', α''.

Fizeau determines α for three temperatures (viz., 20°, 40° and 60° C.) from which he deduces the value for α at any temperature ϑ, and also the variation of α for each degree, that is $\frac{\Delta\alpha}{\Delta\vartheta}$, which is a constant quantity.

He puts the crystal with one side on a platinum support, and places a polished glass plate above the upper surface so as to leave a small interval; by means of a telescope he counts the number of fringes passing beyond certain fixed points of the support, these Newtonian rings being produced by an alcohol flame with salt, and changed by heating the whole apparatus. For the detail of this method we must refer to the original paper—we can here only give a tabular view of the results obtained thereby. At 40° C. the coëfficient of linear expansion in the direction of the axis is α, at right angles to the same α', cubical expansion $c = \alpha + 2\alpha'$, Δ the variation for each degree; t is the temperature at which the body has a *maximum of density*. The unit of α, α', c and Δ is 0·00000001, or *one hundred millionth* of the unit of length or volume.

	α	Δ	α'	Δ	c	Δ	t° C.
Platinum with 0·1 Iridium,	883·847	0·7588	....	....	....	....	.....
Mirror-glass, ...		.....	....	....	2331	4·74	.....
Diamond, ...		.....	....	....	354	4·32	−42°·3
Cuprite, ...		.. ..	....	....	279	6·30	− 4°·3
Beryl, ...	106	1·14	137	1·33	380	3·80	− 4°·2
Quartz, ...	781	1·77	1419	2·38	3619	6·53	.....
Rutile, ...	919	2·25	714	1·10	2374	4·45	.....
Cassiterite, ...	392	1·19	321	0·76	1034	2·71	.....
Periclase (artificial), ...		.....	. ..	...	3129	8·01	.....
Spartalite (ZnO), ...	316	1·86	539	1·23	1394	4·32	.....
Corundum, ...	619	2·05	533	2·25	1705	6·55	.....
Hematite, ...	829	1·19	836	2·62	2501	6·43	.....

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	c	Δ	t° C.
Senarmontite,	5889	1·71	.....
Arsenious acid (artificial),	12378	20·37	.....
Spinel (regular system, hence $a=a'=a''$),			.....
1. Ruby from Ceylon,	1787	7·29	.....
2. Pleonast from Warwick,	1805	5·34	.....
3. Gahnite from Fahlun,	1766	5·19	.....
4. Kreittonite from Silberberg,	1750	5·31	.....

It is evident that t is found by $c-\Delta t=0$; it thus appears that the maximum of density instead of being an exception may be the rule! Fizeau has cut a needle of beryl wherewith he proposes to verify it.—*Poggendorff's Annalen*, 1866, cxxviii, 564–589. G. H.

18. *Expansion of a conductor due to the galvanic current;* by Er. Edlund (Swedish Academy, January, 1866).—When a current passes through a conductor, the latter is heated to a certain temperature, t, above its surroundings and consequently expanded; but it may be questioned whether this expansion is due to the temperature of the conductor, or *whether it is greater*, so that the galvanic current itself produces a peculiar expansion of the conductor through which it flows. That this last is the case has been experimentally demonstrated by Edlund. This expansion might perhaps be called *galvanic;* the usual, *caloric expansion.*

He very carefully measured the actual expansion, E, of the conductor (platinum, iron and brass were used) and the corresponding resistance R. Next he determined the expansion produced by heat alone in the same wire, so that he accurately can determine the temperature, T_1, of the conductor from E, considering this expansion due to the temperature alone. Finally, he carefully determines the influence of temperature on the conducting power of the very same wire; so that he can calculate the temperature T_2, which would correspond to the above resistance R—that is, he determines the actual temperature of the conductor while the current circulates by the resistance it offers.

Edlund found T_2 invariably from 1° to 10° *lower* than T_1—or the actual expansion, E, of the conductor is greater than would be produced by the actual heating, T_2, of the same, this being calculated from the measured resistance, R, of the same conductor. The expansion was not due to a change in elasticity, for the tension of the wire varying from $2\frac{1}{2}$ to $3\frac{1}{2}$ pounds did not change the result. *This galvanic expansion increases rapidly with the intensity of the current*—but according to what law is still unknown.—*Poggendorff's Annalen*, 1866, cxxix, 15–44.

G. H.

II. MINERALOGY AND GEOLOGY.

1. *Note on the use of the name Hudson-river group:* by F. B. Meek.—In the Introduction to the Illinois Paleontology, just published, Mr. Worthen and the writer have some remarks on the impropriety of transferring the name *Hudson-river group*, from the older series of contorted slates and argillaceous sandstones to which it was originally applied (existing in great force along that stream above the Highlands), to the more modern group composed of the *Lorraine shales, Frankfort slates*, &c., with which the true Hudson-river rocks were subsequently confounded.

Since these remarks were in print, I observe we were in error in sup-

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posing that late investigations had brought to light facts casting doubt upon the occurrence of the later types of fossils along *any* part of the Hudson river, in other than the little isolated masses alluded to as occupying synclinal axes in the older rocks, or entangled amongst their contorted strata. The fact, however, that the more modern types of fossils are not known to occur under other circumstances than those mentioned, along the part of that stream regarded as the *typical localities* of the *Hudson-river group* and lying mainly between the Highlands and the region of Albany, while the name, as originally used by Conrad and Mather, was expressly applied by them to this older series, which they regarded as belonging to the Cambrian of Sedgwick, is believed to be a sufficient reason for objecting to the transfer of the name to the later group. Hence if retained at all, it is believed this name should be applied exclusively to the group of rocks for which it was originally intended, and to which it must always carry the minds of those who may look into its origin and history. As it, however, subsequently became very generally also associated with the more recent series already alluded to, it probably could not now be restricted without much inconvenience, to the rocks to which it properly belongs. Consequently the surest, if not the only, way to avoid confusion, will be to strike it entirely from our nomenclature. The name applied to the more recent rocks, in Mr. Worthen's Report on Illinois, is the *Cincinnati* group, from the great development and highly fossiliferous character of these beds at the well-known city of that name in Ohio.*

2. *Note on Bellinurus Danæ, from the Illinois Coal-measures;* by F. B. Meek.—In the Proceedings of the Academy of Natural Sciences of Philadelphia for March, 1865, and again in the Illinois Paleontological Report, Mr. Worthen and the writer have described a new species of crustacean under the name *Bellinurus Danæ*. In both of these publications it is stated that we had not seen the original description published by the founder of the genus *Bellinurus*, nor a full description of it by any other author; but that our species, although closely allied to the forms figured by Prestwich and usually referred to this genus, differs from the characters assigned it by Portlock, Owen and some others, in having its body segments anchylosed, as well as in the position of the eyes.

In the Quarterly Journal of the Geological Society of London, Nov. 1865, p. 490, I observe Mr. Henry Woodward, in speaking of the genus *Bellinurus*, says, "the segments of the abdomen, if not anchylosed in all, are so in most" of the species.

In "The Reader" of Dec. 1866, containing an abstract of the Proceedings of the London Geological Society, it is stated that in a paper read by Mr. H. Woodward, Nov. 1866, "On some points in the structure of the *Xiphosura*," he remarked that this group is "divisible into three genera; 1st. *Bellinurus*, having 5 freely articulated thoracic segments, three anchylosed abdominal ones, and a telson; 2nd. *Prestwichia*, a new

* It has been suggested that Prof. Safford's name, Nashville group, should be retained for this formation. To this I do not seriously object: the only reason for not using it is, that Prof. S. applied it to a group including along with the so-called Hudson river rocks, the upper part of the Trenton. Hence it cannot be conveniently used when we wish to speak with precision of the later so-called Hudson river rocks, as a distinct formation from the Trenton.

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genus, having the thoracic and abdominal segments anchylosed together; 3d. *Limulus*, Müller, having a head composed of 7 cephalic and one thoracic segments, followed by 5 coalesced thoracic somites bearing branchiæ, and one or more coalesced abdominal somites, to which is articulated the telson."

From this I infer, that Mr. Woodward proposes to separate as a new genus under the name *Prestwichia*, those species formerly referred to *Bellinurus*, in which the body segments are anchylosed together. If so, our Illinois species would fall into the latter group, under the name *Prestwichia Danæ*.*

3. *Section of the Rocks of Illinois, from Worthen's Geological Report*, vol. II, p. viii.

		Feet.
	POST-TERTIARY.	
	Drift, Loess, etc.—Clay, sand, pebbles, boulders, etc.	150
	TERTIARY.	
Eocene period?	Clays and greenish sand,	150
	CARBONIFEROUS SYSTEM.	
Carboniferous period.	Coal-measures and Millstone grit.—Coal, shale, clay, limestones, sandstones and conglomerate,	1200
Mountain Limestone or Subcarboniferous period.	Chester group.—Limestone, sandstone and shale,	800
	St. Louis beds.—Limestone and shale,	200
	Keokuk group.—Limestone and shale,	150
	Burlington group.—Coarse, subcrystalline limestone,	200
	Kinderhook group.—Shales, limestone, sandstone, etc.	150
	DEVONIAN SYSTEM.	
Hamilton period.	Genesee division.—"Black slate" and grayish shale,	100
	Hamilton beds.—Dark grayish fetid and lighter, more pure limestones,	120
Upper Helderberg period.	Corniferous and Onondaga beds.—Gray, more or less sandy limestone,	25
Oriskany period.	Oriskany—upper bed.—Quartzose sandstone,	40
	Oriskany—lower beds, or Clear-creek group.—Highly siliceous, very cherty magnesian limestone, usually in thin layers,	200
	UPPER SILURIAN.	
Lower Helderberg period.	Lower Helderberg group, (D. shaly limestone of N. Y. geologists).—More or less magnesian and argillaceous limestone, in thin layers, including flinty concretions,	200
Niagara period.	Niagara group.—Magnesian and argillaceous limestones,	200
	LOWER SILURIAN.	
Cincinnati period.	Cincinnati group.—Limestones, shales and sandstone,	140
Trenton period.	Galena and Trenton beds.—Magnesian and more or less pure limestones,	300
Potsdam or Primordial period.	St. Peter's division.—Pure quartzose sandst.,	150
	Calciferous division.—Magnesian limestones and sandstones,	120 seen.

* Since the publication of the Illinois Report, I observe Quenstedt figures, on tab. 21, fig. 7, of his Handb. der Petref., under the name *Gampsonyx fimbriatus*, a little Crustacean from the Coal-measures of Germany, almost certainly congeneric with an imperfect specimen referred by us, provisionally, to our *Palæocaris typus*. (See Ill. Rep., ii, pl. XXXII, fig. 5*a*.) If Jordan's original figure, however, of the type of the genus *Gampsonyx*, as reproduced by Pictet, and that given by Bronn, are even nearly accurate, the typical specimen of our genus *Palæocaris* must be very distinct from *Gampsonyx*.

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4. *Geological Survey of Canada.—Catalogue of the Silurian Fossils of the Isle of Anticosti, with descriptions of some new genera and species;* by E. BILLINGS, Paleontologist, F.G.S. 93 pp., 8vo, with 42 wood-cuts. Montreal, Nov., 1866.—The whole number of species enumerated and described in this valuable memoir is about 330, of which some 130 are here for the first time made known to Science. Altogether they represent over 70 genera of *Protozoa*, *Radiata*, *Mollusca*, and *Articulata*. Of these genera, the following are new, viz., *Ischyrinia*,—a genus of bivalves apparently allied to the *Trigoniidæ*; *Streptoceras*, a Cephalopod like *Ormoceras* but with a trilobate aperture like *Phragmoceras*,—and *Sœrichnites*, supposed to be the tracks or trails of a Mollusk. In enumerating the species previously described, full references are given to the works in which the descriptions were originally published; while the larger portion of the new species are illustrated by good wood-cuts, printed in the text.

In regard to his genus *Pasceolus*, published some time back, the author says he thinks the evidence upon which it has been referred by others to the *Cystidea*, not conclusive; and he denies that he had, as some have thought, regarded it as presenting Ascidian affinities. He also doubts its identity with *Cyclocrinus* of Eichwald.

On pages 75 to 82, he has some highly interesting and instructive remarks on the paleozoic rocks and fossils of Anticosti and New Brunswick, and their relations to those of Canada, New York and Great Britain. It would be impossible to give here, even an intelligible abstract of the whole of these remarks; but it is worthy of note that he places the *St. John's group* of New Brunswick, consisting of about 3000 feet of Black slates and Sandstones (conformably underlaid by a series of rocks very like the Cambrian) *beneath the Potsdam sandstone*, and on a parallel with the Lower Lingula flags of Wales. He mentions seeing, from the St. John's group, species of *Orthis*? *Paradoxides*, *Conocephalites*, *Arionchlus*, *Microdiscus* and *Agnostus*.

The Potsdam sandstone he considers divisible into lower and upper, the first or lower division being represented by the sandstones and limestones of the north shore of the Straits of Belle-isle, and the rocks, which in Vermont are called the *Georgia slates*, and Red sandstone characterized by *Olenus Vermontana*, *O. Thompsoni*, *Conocephalites Adamsi*, &c., also probably including the St. John's slates (of Jukes) Newfoundland, and the Paradoxides beds near Boston.

The upper Potsdam he views as being composed of the Minnesota and Wisconsin trilobite beds, and probably the upper part of the Potsdam sandstone of Canada and New York.

The Calciferous he likewise divides into lower and upper, the first being the original typical Calciferous beds, and the latter (not known in Canada or New York) occurring in Newfoundland, where it is over 1000 feet in thickness.

Above the latter he places the Lévis formation, and next the Silery. Between the Lévis and the Calciferous formations, there is a great paleontological break, as there is also between the Lévis and the Chazy above, many of the *Trilobites* in the Lévis being closely allied to those of the Upper Lingula flags and Tremadoc slates.

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This work will be indispensable to those wishing to study the rocks and fossils of Anticosti, as well as highly interesting, from the general bearing of some of the author's views, to all engaged in investigating the Silurian rocks everywhere.

5. *Tertiary of North and South Carolina;* by T. A. CONRAD. (From a letter to one of the editors, dated Philadelphia, Jan. 31, 1867.)—The Tertiary strata of North and South Carolina are well worthy of a more thorough study than they have yet received. Prof. Tuomey has described some disturbed Eocene strata in South Carolina, in which he finds many specimens of the following Cretaceous forms: *Ammonites placenta*, *Terebratula Harlani*, *Gryphæa mutabilis*, and *Spondylus gregalis*. He remarks that the beds containing these fossils are of the same age as the conglomerate at Wilmington, N. C. That this mixture of Cretaceous and Eocene species is accidental is clearly proved by their never having been found in the undisturbed strata of older Eocene in Alabama and Mississippi, and especially by the occasional presence of Cretaceous fossils in the Miocene of Cape Fear river, N. C. No one would believe that they lived through the Eocene period and escaped alive into that of the Miocene. Prof. Emmons remarks that *Belemnitella mucronata*, *Exogyra costata*, and *Cucullæa vulgaris* (cast) are all found in the Miocene, and he regards their presence as accidental.

The *Ostrea Georgiana*, according to Tuomey, is associated, near Aiken, S. C., with *O. Alabamiensis*, which is a species of the siliceous sand stratum of Claiborne. The buhrstone of South Carolina and Georgia, by their fauna, would appear to be synchronous with the above-mentioned sand group of Alabama. The *O. Georgiana* may be of this age, or immediately succeeding it, but does not occur in the older Eocene, though it might be inferred from some accounts of Shell Bluff that were associated. Mr. Ruffin has published a diagram of Shell Bluff, but unfortunately he does not mention in what stratum he found *O. sellæformis*, but he remarks that *O. Georgiana* "is seen in the upper part of the perpendicular face of the cliff, above the marl of the great Carolina bed" (to which *O. sellæformis* belongs) "and there separated from it by a body of from four to ten feet in thickness. . . . This complete separation should forbid the belief that the deposit of gigantic oyster shells belongs to the same geological formation as the great Carolinian bed below."

Whatever position in the Eocene may be assigned to *Ostrea Georgiana*, it can have but one horizon throughout its vastly remote localities, and appears everywhere to have been suddenly introduced into the Eocene fauna, and to have had a short existence compared with *O. sellæformis*, as a deposit of six feet is the greatest thickness recorded.

6. *On Human remains in Belgium;* by MR. DUPONT. (Continuation of the account on pages 121, 122, of this volume.)—Mr. Dupont has very recently explored three other caverns in the valley of the Lesse; bringing up to twenty-two the number of those which he has examined in the vicinity of Dinant, since the commencement of his researches, undertaken at the expense of the State upon the recommendation of the Academy. These three new caverns bear the names of Cave of Praule, Cave of the Germans, Cave of the Nutons of Gendron. If they have furnished few new facts in regard to the study of the quaternary period,

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they have presented facts important for the understanding of the relations between the human race which inhabited the country at the period of the reindeer and that which succeeded it. We will say a few words concerning the results obtained in these new explorations.

The Cave of Praule is situated five hundred meters above Furfooz, on the left bank of the Lesse, about thirty meters above the river. Breadth of the cavern, six meters; length, three and one-half meters in the middle; mean height, two meters. On the sides are two narrow galleries having a depth of four and of eight meters respectively. The quaternary sediments there were of small thickness; they showed at the bottom, immediately above the limestone floor, a thin layer of the sandy-argillaceous stratified deposit with rolled pebbles and gravel arranged in seams not continuous; in a word, the most decided characters of the lehm or middle period of the quaternary formation of the province. That deposit contained a humerus and a canine of a great bear. The layers superimposed upon the preceding are, as ordinarily, yellow pebbly clay; they are less than a meter in thickness; they contained, especially at the bottom, bones and some worked flints. The bones indicate the following species: bear, wolf, fox, horse, reindeer, goat. The flints, all worked in the knife form, are few, and are derived from the cretaceous deposits. These facts confirm the placing of the remains of the reindeer period in the pebbly clay, and the priority of that age to the deposition of that immense layer of clay. The small number of bones and of worked flints indicates a brief residence of man in that cavern, which seems nevertheless to have been perfectly adapted for habitation, being easy of access, spacious, well lighted, and very dry at that period, as is shown by the absence of stalagmites between the lehm which then covered the floor of the cavern, and the pebbly clay which is of a date subsequent to man's residence there.

The cave of the Germans is not so much a cavern as a simple shelter furnished by a dolomitic rock (stratum III. of the Carboniferous limestone), which overhangs, and under which the gypsies still establish themselves during their journeyings; whence the name which has remained to it, the gypsies being called Germans in that district. Shelters of this nature are quite numerous on the Lesse, and they are all known under the name of caves of the Germans. The following is the section of the one in question, which is situated near the road from Hulsonniaux to Celles: 5, at the level of the Lesse, rolled pebbles, transported from Ardennes, consolidated with gravel; 4, above, yellow clay with dolomitic pebbles; 3, Loess; 2, recent alluvium, formed of little seams alternately sandy and argillaceous like the lehm; 1, the same, modified and mixed with vegetable remains; in this last bed, which forms the present floor of the cavern, are found some flints of the knife form and a small hatchet of sandstone, polished and irregular in surface.

The third cavern, called the cave of the Nutons of Gendron, is situated two thousand five hundred meters (in a straight line) above the caverns of Furfooz, on the left bank of the Lesse; but as the river describes numerous curves between the two localities, the real distance is more than eight kilometers. This cavern is at an elevation of about seventy

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meters from the river, near the village of Gendron: it is excavated in the *peammite* formation of Le Condroz. That is a schistose formation with some calcareous beds alternating. The limestone has produced in this cavern stalactites, which have cemented the schistose beds together, and have preserved it from the caving-in which is very frequent in caverns of this sort. Width of the cavern at the entrance two and one-half meters; length, fourteen meters; it terminates in the form of a wedge. When Mr. Dupont visited it for the first time, he was able to penetrate only to a distance of eight meters; at that point the passage was obstructed by little columns of stalactite and cones of stalagmite. The soil is formed of a sort of mold apparently derived from the decomposition of leaves, and resembling the detritus known under the name of heath-mold (terre de bruyère). It rested on a layer of yellow clay with pebbles of schist, without ornaments or remains of industry, itself resting upon the rock. The soil covered the clay only from a point eight meters from the entrance, and was itself covered by stalagmite, which attained, in some places, a thickness of six decimeters.

In examining this soil, a great number of human bones were found, which were recognized as belonging to seventeen skeletons. Although the bones were all broken, the laborers were able to observe that the remains of the head, then those of the arms and trunk, then those of the legs, were discovered successively over a length of less than two meters. They discovered afterward, in the same order, a second, a third, then a fourth row of imperfect skeletons. Afterward a little skeleton was discovered laid transversely. Then the longitudinal arrangement of the bones again presented itself; the remains of the head toward the entrance, those of the limbs toward the inmost part of the cave. Another little skeleton was found, also placed transversely, and finally two others extended, like those of the preceding rows, parallel to the axis of the cavern. Among the human bones were found bones of foxes, badgers, hens, &c. At the entrance of the cavern was found a very small fragment of cretaceous flint in the form of a plate, with three fragments of coarse pottery. Upon the slope of the escarpment, immediately under the opening of the cave, lay two large plates of schist differing from that of the cave and of the surrounding country: one of these plates measured 1·50 meters in length by 85 centimeters in breadth; the other 1·05 meters by 1·65.

After the comparative examination which was made by Mr. Bruner-Bey of the human remains found in this cavern, one may say, in general, that none of the bones differs notably from the type of the reindeer period. As during that age, there are two forms of the lower jaw, one with horizontal branches very low and stout, the other with branches more elevated and more slender. Nevertheless, the genian eminence, triangular in the external aspect, and the bifid genian eminences in the interior are here well marked, although the chin, always rounded, is yet nearly vertical. As in the jaws of the reindeer period found at Furfooz, the angle of the chin, in the pieces where it exists, is rounded, turned inward, and very much inclined; the condyle and the glenoid cavity have the same characters in the series from Furfooz and from Gendron. The molars found have generally the normal size, and the wearing of the crown

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is circular in all. In one jaw with very high horizontal branches, the two first molars are of equal size: that is a fact which is observed also in the jaws of the reindeer period of Furfooz. The molars have likewise only four tubercles. Finally, in two pieces there exists also a strongly marked symphyseal prognathism. One jaw of an old man presents, besides this considerable prognathism, genian eminences much blunted, but the chin is prominent. The most perfect fragment of the upper jaw is orthognathous. Except the middle incisors, the teeth are small. Among the separate teeth is noticed a very stout canine. Two temporal bones belonging to individuals not of the same age, also exhibit perfectly the peculiarities of the type of the reindeer period; the mastoid processes are short and rounded; the glenoid fossæ are narrow and deep; the post-mastoideal part is very thick, and the depressions of the inferior cerebral lobes on the inner surface are deep. This last peculiarity is noticed likewise on a fragment of a frontal bone of the ordinary thickness; it bears all the characters of the ancient race: external orbital process and root of the nose very broad; superciliary arches very prominent; glabella triangular and depressed. A femur, scarcely epiphysized, is forty-two centimeters in length; its circumference below the trochanter minor is eleven centimeters; the length of the neck is twenty-two millimeters; the circumference is one hundred and two millimeters; it exhibits, moreover, the double curvature peculiar to the race of Furfooz, the very large trochanter minor; the rough line is very prominent, although flattened.

From what has been said above, it is seen that the Cave of the Nutons of Gendron was a sepulchral cavern. But when did it serve that purpose? This is what Mr. Dupont says on that point.

The bones and the earth which encloses them are above the yellow pebbly clay. Now, in the province of Namur, the remains of the reindeer period are always found beneath the yellow pebbly clay. This rule is confirmed by each new exploration, without having offered as yet a single exception. The superposition of the ossiferous soil above the pebbly clay demonstrates then that the skeletons in question are of date subsequent to the reindeer period. It remains to endeavor to refer them to a definite time within the period limited on the one side by the deposit of pebbly clay, and on the other by the present time. The mode of burial indicates great antiquity; it can scarcely be met with except in the dolmens.

We have said that three fragments of coarse pottery were found at the entrance of the cavern. Mr. de Mortillet, who has examined them, describes them as follows:

"Two of the fragments evidently formed a part of the same vessel, and traces are seen of the bourrelet which formed the opening; the other is red on one side, black on the other. This pottery was made by hand, without any use of the wheel. It is very poorly baked, and consequently has not passed through the oven. Powdered calcite was mixed with the clay, to give it consistency, and prevent it from cracking while drying and especially on the approach of fire, the baking being done probably before the vessels were perfectly dry. The outer surface of the fragments shows a polishing which has left numerous little striæ, as if it had been done with a bunch of grass or straw dipped in a barbotte (fine

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clay suspended in a large quantity of water). These three fragments offer then all the characters of very ancient pottery. In material, in composition, they seem to belong to the plastic art of the dolmens; but the border which surrounds the opening on two of them and the application of a barbotte would perhaps prove them to be a little more recent. It seems then more natural to refer them to the period of transition between the stone and the bronze. We are thus brought, says Mr. Dupont, to consider this race as the same that constructed those fortresses with cyclopean walls of which numerous examples are found in the province, and as belonging to the same age with the celebrated remains collected at Chauvaux by Mr. Spring."

In regard to the origin of the humus or soil which covered the skeletons, it is quite difficult to explain. It is certain that the existence of the humus, and consequently the introduction of the leaves which formed it, is more ancient than the layer of stalagmite which covers it, a layer which attains, in certain places, a thickness of six decimeters. It is certain also that, since the formation of the layer of stalagmite, no more humus has been formed, for the stalagmite contains none and is covered by none. It follows from this that a long space of time must have passed since the introduction of the leaves, for the rock in which the cavern is found is formed of schist, in which the limestone appears only in rare beds fifteen or twenty centimeters in thickness. This last remark agrees then with the preceding in attributing to the burials a very remote antiquity. If now one recalls the discovery, at the entrance of the cavern, of large plates of schist, not derived from the walls of the cavern, nor from the surrounding country, and consequently evidently brought from elsewhere, one would be tempted to see in these plates the fragments of a flag-stone which had closed artificially the entrance of the cavern, and had been subsequently removed and broken. If such was the case, the presence of the soil or rather of the decomposed leaves under the stalagmite would be explained with difficulty by a natural introduction. Perhaps it might be better explained by supposing, for burials of that remote period, a custom still used by the Peaux-Rouges of Brazil and the New-Caledonians, a custom which consists in wrapping corpses in a layer of leaves, and placing them thus enveloped in caves, in dolmens, and hanging them upon trees. Admitting this supposition, we should understand why dolmens are so rare in the province of Namur, numerous caves presenting themselves in many places to the men of that age to serve exactly the purpose of dolmens, and exempting them from erecting monuments whose construction must then have required great labor. We are thus led to consider sepulchral caverns as natural dolmens, which were used in the period of the reindeer or in the period of polished stone.

7. *Volcanic eruptions in Hawaii;* by Rev. T. Coan. (From a letter to J. D. Dana, dated Hilo, Hawaii, Aug. 31, 1866.)—I wrote you Feb. 27th of an eruption in Mokuaweoweo on the summit of Mauna Loa. This was first noticed at Hilo about the last of Dec. 1865, and we continued to see the light and smoke until the last of April, or four months. I am told by Mr. Richardson, who keeps a good hotel at Kilauea, that from his place he occasionally saw steam rising from that crater during all

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May. It now seems quite extinct, and though the action for two months was vigorous and the light vivid, the lavas never overflowed the rim of the great crater or burst out laterally. Like most of the eruptions in Kilauea, the action was confined within the walls of the old crater.

In May, June, and July, the action in Kilauea was greatly increased. It was often intense and vehement. The old south lake (Halemaumau) overflowed several times, and a chain of lakes, three, four, and sometimes five or six, opened on a curved line from N.W. to N. and N.E. from the old lake. The action in this chain of lakes was often violent. Jets of lava were thrown 50, 100 and 200 feet high; the lakes overflowed, and fiery rivers seethed along the northern and eastern walls of the crater, sweeping around beyond the eastern sulphur banks. This curved line of action is about four miles long, and the igneous stream was in some places half a mile wide. The new deposits lie in strata of 50 to 100 feet in thickness. Cones and domes of lava were also raised, and yawning fissures opened, interrupting the traveller in crossing the bottom of the crater. At different times, and sometimes for many days, the fiery flood swept up to the path by which visitors go into the crater and cut off all ingress by the usual route. Many parties were obliged to view the surging waves from above, without being able to enter the crater. Occasional earthquakes shook down avalanches of rocks from the walls of the crater, and frightened the spectators.

During all this action, extending more than half round the crater, the central area, an elevated plateau, remained undisturbed, unless it may have been raised quietly, which is probable, by the forces below. This central table has been, for years, 200 feet higher than the surrounding area between this and the outer walls. For a few weeks past the action in Kilauea has been feebler, but we have no assurance that it will not increase at any time.

There has been a vast filling up and an upraising in Kilauea since 1840. Should you now visit it, you would recognize nothing except the outer walls and the surrounding regions. Internally *all* is changed and all is new. The lavas now stand higher in the crater than before the great eruption of 1840. Whether the walls will sustain the pressure until the vast pit fills and overflows the outer rim, or whether they will be rent and give lateral vent to the fusion, as in 1840, remains to be seen. And whether the cessation of action on Mt. Loa, about the last of April, had any influence on the increased action in Kilauea in May, June and July, we leave for the geologist to determine.

8. *Notice of a Human Skull, recently taken from a Shaft near Angel's, Calaveras County;* by J. D. Whitney.—This skull was taken from a shaft sunk on a mining claim at Altaville, near Angel's, in Calaveras county, by Mr. James Matson. By him it was given to Mr. Scribner, of Angel's, and by Mr. Scribner to Dr. Jones. Mr. Matson states that the skull was found at a depth of about one hundred and thirty feet, in a bed of gravel five feet in thickness, above which are four beds of consolidated volcanic ash, locally known as "lava;" these volcanic beds are separated from each other by layers of gravel, and Mr. Matson gives the following as the section of the various deposits passed through in sinking the shaft, which is one hundred and fifty-three feet deep, to the bed rock:

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1.	Black lava,	40 feet.
2.	Gravel,	3 "
3.	Light lava,	30 "
4.	Gravel,	5 "
5.	Light lava,	15 "
6.	Gravel,	25 "
7.	Dark brown lava,	9 "
8.	Gravel,	5 "
9.	Red lava,	4 "
10.	Red gravel,	17 "
		153 feet.

The skull was found, according to Mr. Matson, in bed No. 8, just above the lowest stratum of lava. With the skull were found fragments of silicified wood, the whole being covered and partly incrusted with stony matter, so that the fact of its being a skull was not recognized until after it had passed into Mr. Scribner's hands, by whom it was cleaned and presented to Dr. Jones.

The skull is said by Mr. Matson to have been taken from the shaft February 25th, 1866, and it came into my hands in the July following, when I immediately proceeded to the locality, but found the shaft temporarily abandoned and partly filled with water, so that it was impossible at that time to make any farther search in the bed from which the skull was procured. A careful inquiry into all the circumstances of the alleged discovery, and an interview with all the persons who had been in any way connected with it, impressed upon my mind the conviction that the facts were as stated above, and that there was every reason to believe that the skull really came from the position assigned to it by Mr. Matson. Still, as it is evidently highly desirable that as large an amount of evidence as possible should be accumulated in regard to a discovery of so much importance, I made arrangements that I should be notified whenever the shaft was reopened and the water taken out, and hope at a future meeting to be able to lay before the Academy the results of a personal examination of this interesting locality, and of further excavations in the bed from which the skull was taken.

Assuming the correctness of Mr. Matson's statements, this relic of human antiquity is easily seen to be an object of the greatest interest to the ethnologist as well as the geologist. The previous investigations of the Geological Survey have clearly demonstrated the fact that man was contemporaneous with the mastodon and elephant, since the works of his hands have been repeatedly found in such connection with the bones of these animals that it would be impossible to account for the facts observed on any other theory. (See Geology of California, vol. i, p. 252.) But in the case of the skull now laid before the Academy, the geological position to which it must be assigned is, apparently, still lower than that of the mastodon, since the remains of this animal, as well as the elephant, which are so abundantly scattered over this State, are always (so far as our observations yet extend) limited in their position to the superficial deposits, and have never been found at any considerable depth below the surface. There is every reason to believe that these great proboscidians lived at a very recent date (geologically speaking), and posterior to the epoch of the existence of glaciers in the Sierra Nevada, and also after

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the close of the period of activity of the now extinct volcanoes of that great chain. In fact, they belong to the present epoch. The bed, on the other hand, in which this skull was found, must have been deposited at a time when the volcanoes of the Sierras were still in vigorous action, and, as seems to us highly probable from a careful consideration of the geological structure of the region, previous to the glacial epoch of the Sierra, and also previous to the erosion of the cañons of the present rivers. No pains will be spared, however, to investigate all the conditions of the occurrence of this skull, and they will be fully reported on at a future time.

The portions of the skull which are preserved are, the frontal bone, the nasal bone, the superior maxillary bone of the right side, the malar bones, a part of the temporal bone of the left side, with the mastoid process and the zygomatic process, and the whole of the orbits of both eyes. The base of the skull is imbedded in a mass of bone breccia and small pebbles of volcanic rock, incrusted with a thin layer of carbonate of lime, which appears once to have extended over the whole surface of the skull and of which a considerable portion still remains, the rest having been removed apparently in the process of cleaning. Under the malar bone of the left side, a snail shell is lodged, and partly concealed by the breccia of bone wedged in the cavity. This shell is the *Helix Mormonum*, according to Dr. Cooper, a species now living in the region where the skull was obtained. Although not competent to express a decided opinion on the subject of the ethnological relations of this skull, I should suppose that it belonged to the type of the Indians now inhabiting the foot-hills of the Sierra. It is certain that the facial angle is not one indicating a low order of intellect. The skull, however, seems to have been very thick and solid. It will be placed in the hands of competent craniologists for examination and description, as soon as reliable information has been obtained with regard to its occurrence, or whenever all has been ascertained that can be.—*Proc. California Acad. Nat. Sci.*, iii, 277.

9. *Notice of the occurrence of the Silurian Series in Nevada;* by J. D. WHITNEY.—At a meeting of the Academy in May last, I gave some account of the geology of the state of Nevada, with particular reference to the age of the stratified deposits occurring there, as determined from the collections of fossils brought from that region to the office of the Geological Survey, by J. E. Clayton, and various members of our corps. In that communication I spoke of the probable future discovery of rocks older than the Carboniferous or Devonian, in the mountain ranges near Austin. This expectation has been realized, and we are now in possession of a very interesting collection of fossils, obtained by Mr. A. Blatchley, in the vicinity of the Hot Creek Mining District, about one hundred miles southeast of Austin. This collection enables us to state positively that both Upper and Lower Silurian rocks occur in that district, and that they are well filled with fossils; not less so, indeed, to judge from the specimens received, than the strata of the same age in New York, Ohio, Iowa, and Wisconsin, which they resemble in a most marked degree, both lithologically and paleontologically.

The fossils from the Hot Creek district are mostly weathered out on the surfaces of thin slabs of bluish-gray argillaceous limestones, and are

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crowded together in the same profusion with which they have often been noticed by myself and others as occurring in the Lower Silurian shales and limestones of the Wisconsin lead region, around Big Bay des Noquets, and in many other localities in the country bordering on the great lakes.

Both the upper and lower divisions of the Silurian appear to be represented by the fossils of the Hot Creek District; but the Lower Silurian seems to be much the most prolific in fossils, as is the case in Wisconsin and Iowa. The particular period to which these Lower Silurian forms may be referred is the Trenton, including the Chazy, Birdseye, Black river and Trenton limestones of the New York geologists, and the Buff and Blue limestones of the western surveys. Nearly all the prevailing types of the eastern rocks of this age are represented in the Hot Creek collection, namely, Brachiopods, Gasteropods, Cephalopods, Crinoids, Trilobites, and Corals; and there are among them several of the most widely-distributed and most characteristic species of the Lower Silurian. The following have been identified: *Maclurea magna*, a characteristic Chazy species, and *Pleurotoma lenticularis*, *Orthis testudinaria* and *Chætetes lycoperdon*, all of which are abundant in the Trenton limestone of New York, and the rocks of the same age farther west. Among the fragments of Trilobites, two or three different genera may be recognized, especially *Asaphus*, which is represented by a species apparently new. There are also fragments of Crinoids or Cystids closely resembling the species figured by Hall, in the Paleontology of New York, vol. i, as *Echino-encrinites anatiformis*.

The rocks containing the above-mentioned fossils crop out in the sides of a deep cañon; and overlying them, at a perpendicular distance of about a thousand feet, is a series of beds containing numerous fragments of corals and crinoids, silicified and weathered out from the surface of a bluish-gray limestone, which I refer without much doubt to the age of the Niagara limestone of New York. Among the corals, *Heliolites spinipora* and *Syringopora* are recognizable; and among the crinoidal fragments are stems of what appears to be *Caryocrinus ornatus*.

With the exception of the Potsdam sandstone fossils, described by Meek and Hayden as occurring at the base of the fossiliferous series, in the Black Hills, no recognizable Silurian forms have been observed by geologists, in the Rocky mountains, or anywhere to the west of them, unless possibly in New Mexico. The Silurian series, with the possible exception of the Potsdam sandstone, seems to be entirely wanting in the Rocky mountains proper, the Black Hills being a sort of outlier of the main ranges, and lying as far east as the one hundred and third to the one hundred and fifth meridian. Dr. Hayden says, in his paper, on the Geology and Natural History of the Upper Missouri, published in 1862, that "hitherto no indications of the existence of any other member (than the Potsdam sandstone) of the Silurian period have been discovered along the eastern slope of the Rocky mountains within the boundary of the United States." He considers it probable that the Potsdam sandstone is represented in the Rocky mountains, although no fossils of that member of the series have been as yet discovered anywhere to the west of the Black Hills.

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On the Mexican Boundary Survey, a few fragments of fossils were found in the superficial detritus, near El Paso (longitude 106°), which indicated the existence of Silurian rocks in that vicinity; but none appear to have been found in place. Professor Hall remarks that "the specimens referable to strata of this age (Devonian and Silurian) are few, and they are in such condition as to give little satisfactory information regarding the rocks in place." The specimens obtained are figured in the Mexican Boundary Report, but not described, nor is their locality accurately stated.

Dr. Newberry, in his Report on the Geology of the Colorado river region, refers the lower portion of the strata exposed in the grand cañons of that river to the Devonian and Silurian series; but as no recognizable fossils were discovered by the Ives expedition from any rocks lower than the Carboniferous, this reference can only be taken as expressing a conviction based on lithological characters and stratigraphical considerations.

In view of the facts above cited, it will be seen at once how interesting this discovery is of undoubted Silurian rocks west of the Rocky mountains; and the more so, since we have in this remote region a recurrence of conditions and forms of animal life so closely allied to those with which we are familiar in the states east of the Mississippi. It is a very remarkable fact that these rocks have not been discovered in the Rocky mountains; and should farther explorations fail to reveal their presence, it will throw a new light on the history of the physical development of the central and western portions of this continent. Taking into view what has now been communicated, and what was stated in my previous paper in regard to the existence of the older stratified rocks in the Silver Peak District, it will appear that Dr. Newberry's generalizations were, in all probability, correct, and that we may expect to find in southern and southwestern Nevada the outcropping fossiliferous edges of the strata underlying the Carboniferous of the great Arizona or Colorado plateau, and that they will be proved to occupy an extensive area, and to yield a profusion of organic remains.

Among the specimens collected by Mr. Blatchley, as also by Mr. Clayton, Mr. Melville Attwood, and Dr. C. L. Anderson, and now at our office, there is a considerable number which demonstrate the existence of an extensive freshwater Tertiary deposit in Nevada. This formation, which belongs to a very late Tertiary epoch, evidently occupies a considerable area, as our specimens come from localities hundreds of miles distant from each other. The existence of any marine formation more recent than the Jurassic, in Nevada, has not yet been proved; but, as Mr. Gabb obtained evidence, in 1864, of the occurrence of rocks of Cretaceous age on Crooked river, in Oregon, east of the Cascade Range, it is possible that this member of the series may yet be discovered in Nevada.

All the fossils referred to in this and my previous communication on the geology of Nevada, will receive, in due time, thorough investigation at the hands of Messrs. Meek and Gabb, or other competent paleontologists; and we expect that our collections from that state will be largely increased during the present year.—*Proc. California Acad. Nat. Sci.*, iii, 307.

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10. *Eozoön.*—At a meeting of the Natural History Society of Montreal in January last, Dr. Dawson exhibited a photograph of a remarkable specimen of *Eozoön Canadense*, found the past summer in the Laurentian limestone of Tudor, Canada West, by Mr. Vennor, of the Canadian Geological Survey, and which had been examined and described for Sir W. E. Logan by Dr. Dawson. The rocks at Tudor and its vicinity, which, according to the observations of Mr. Vennor are Lower Laurentian, have experienced less metamorphism than is usual in formations of that age, and this peculiarity gives especial interest to the present specimen, which is contained in a rock scarcely altered and in a condition not essentially different from that of ordinary Silurian fossils.

The matrix is a coarse laminated limestone of a dark color, and containing much sand and finely comminuted carbonaceous matter. The fossil itself is of a flattened clavate form, about six and a half inches in length, and with the septa of its chambers perfectly preserved, exhibiting on one side a well defined marginal wall produced by coalescence of the septa, and apparently traversed by small orifices. Under the microscope the minute structures of *Eozoön Canadense* can be detected, though less distinctly perceived than in some of the specimens mineralized by serpentine. In some of the chambers there are small amorphous bodies containing pointed siliceous spicules, which seem to be the remains of sponges that have established themselves in the cells after the animal matter of *Eozoön* had disappeared.

The importance of this specimen was pointed out as establishing the conclusions previously arrived at from the study of the remains of *Eozoön* included in the serpentinous limestones, and as overthrowing the objections raised in some quarters to the organic origin of *Eozoön*. The specimen will be taken to England by Sir W. E. Logan, and full details of its characters will be communicated to the Geological Society, along with some other recent discoveries tending to the establishment of a second species of *Eozoön*.—*Montreal Gazette*, Jan. 29, 1867.

11. *On Fossils in the Auriferous rocks of California;* by W. P. Blake, (from a notice of the meeting of the California Academy, Aug. 20, 1866.) —Prof. Blake read a paper upon a "New Locality of Fossils in the Gold-bearing Rocks of California," and exhibited specimens of Ammonites from a cut on the line of the Central Pacific Railroad, near Colfax. Although the specimen exhibited was quite perfect, it was not sufficiently so to enable the septæ to be seen. Prof. Blake remarked that these fossils were undoubtedly of the secondary period, and that they were apparently specifically identical with those from the American river, in the same vicinity, of which he had sent photographs to Mr. Meek, in 1863, and afterwards noticed the same at a meeting of the Academy in September, 1864; he also thought them identical with the species found at Bear Valley, Mariposa county. Prof. Blake also exhibited the tooth of an extinct elephant, a *molar*, found in the auriferous gravel near Michigan Bluffs; also, shark's teeth and other marine remains from Tulare valley; these remains were found by him at an elevation of at least twelve hundred feet above the sea, and probably belong to the Post-pliocene period.

Prof. Blake alluded to a "Quarry of Gold-bearing rock" in Placer county, known as the Banker or Whisky Hill mine, where no regular

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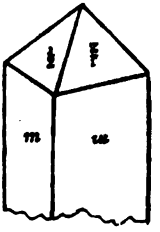
quartz vein exists, and the rock of the hill is profitably worked; some forty tons per diem are crushed, yielding from two to twenty dollars per ton—averaging from five to six dollars per ton.

12. *On the Crystalline form of Pachnolite;* by A. DesCloizeaux. (From a letter to J. D. Dana, dated Dec. 6, 1866.)—Pachnolite is not quadratic as has been stated. Its crystals are much less simple. They belong to the monometric system, and appear to me to be always macled, in the same manner as are those of amphibole. As only a single summit is visible, the crystals being retained in the gangue by the opposite one, it seems as if we were dealing with a right rhombic prism. The four faces of the terminal octahedron are actually of the same kind, and belong to a positive hemi-octahedron, $b\frac{1}{2}$. The crystals therefore appear as in the annexed figure, the axis of revolution being normal to the plane bisecting the acute angle of the fundamental prism. We may admit as a mean—



		Calculated.	Observed.	
m on m in front,	=	98° 34′	98° 40′	
m on m lateral,	=	81 26	81 43	macle.
$b\frac{1}{2}$ on $b\frac{1}{2}$ (planes $\frac{1}{2}$ in figure) adjacent,	=	108 15	108 15	
$b\frac{1}{2}$ on $\frac{1}{2}q$ adjacent,	=	94 13	94 13	macle,
m on $b\frac{1}{2}$ adjacent,	=	153 37	153 46	
$\frac{1}{2}q$ on $b\frac{1}{2}$ opposite,	=	52 46	52 46	

Edges $\frac{b\frac{1}{2}}{b\frac{1}{2}} : \frac{m}{m}$ adjacent,	=	146° 45′
Base $p : m$,	=	90 20
Plane angle of the base,		98 33 54″
Plane angle of the lateral faces,		90 16 48

The plane of the optic axes is perpendicular to the plane of symmetry, and makes an angle of about 10° to 15° with a normal to the edge $\frac{m}{m}$, and an angle of about 23° 15′ to 18° 15′ with a normal to the edge $\frac{b\frac{1}{2}}{b\frac{1}{2}}$. One of the bisectrices is normal to the plane of symmetry; the other makes with the edges $\frac{m}{m}$ and $\frac{b\frac{1}{2}}{b\frac{1}{2}}$ the same angles as the plane of the axes: but I have not yet been able to ascertain which of these is the bisectrix of the *acute* angle of the axes. The former is *negative*. As it has been impossible to cut a single thin plate normal to the bisectrices, it has not been possible to study the dispersion of the optic axes. The crystals rest upon small, translucent, crystalline laminæ, which appear to possess different optical properties. Is this mineral arksutite? These laminæ appear to make a transition stage between cryolite and pachnolite,

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III. BOTANY.

1. *Salices Europæa;* recensuit et descripsit Dr. FRIDERICUS WIMMER. Breslau, 1866. pp. 286, 8vo.—While awaiting the appearance of the general elaboration of the order, contributed by Dr. Andersson to the Prodromus, and of the *Icones Salicum* he has also prepared, we receive this beautiful volume, in which Dr. Wimmer, restricting his attention to the European Willows, has revised these with much detail and evidently with very great care. The work is written throughout in Latin. There is a full account of the literature of the subject, of the structure and morphology, and of the various systematic arrangements of the species which different authors have proposed. Dr. Wimmer himself arranges the Willows of Europe under eleven tersely characterized tribes, each comprising from one to six species. He admits only 81 to the rank of genuine species, reducing a great number to mere synonyms, and having well characterized these in the first half of his volume, he devotes the rest to *Salices hybridæ*. These hybrids, 57 in number, and chiefly named according to their parentage, are disposed under fourteen sections, and their synonymy is fully indicated. The whole work gives the impression of being thoroughly reliable and excellent. A. G.

2. *Le Specie dei Cotoni descritte da* FILIPPO PARLATORE. Florence, 1866.—Professor Parlatore's essay upon the long-vexed question of the species of Cotton was called forth by a Royal Italian Commission, and is dedicated to its President, Devincenzi. The letter-press, of 64 pages, 4to, is divided into a general history of cotton-plants, in Italian; and the description of the species, with the characters and full synonymy, are in Latin, but the farther details in Italian. He describes seven species (besides referring to as many doubtful ones): *G. arboreum*, or Tree Cotton; *G. herbaceum*, the common herbaceous Cotton; *G. Barbadense*, or Sea-Island Cotton; *G. religiosum*, or Peruvian Cotton; *G. hirsutum*, or Siamese Cotton; *G. Taitense*, as a new species, from Tahiti, which had been long variously confounded with others; and *G. Sandvicense*, also as a new species from the Sandwich Islands; but this has already been published by Dr. Seemann, under Nuttall's name of *G. tomentosum*. These species are all illustrated in a separate atlas of six plates, in elephant folio, beautifully exhibiting them in specimens of the natural size, in good lithography, all but the last two printed in colors. Our copy of this fine work is presented by the President of the Royal Commission, through the author.

Coniferæ, &c.—It is well known that Prof. Parlatore has elaborated the *Coniferæ* for the Prodromus. We have from him his study of the organography of the flower and fruit of this order, a memoir, contributed to the Annals of the Museum of Natural History at Florence, written in Italian; in quarto, with three folio plates, filled with structural details. Botanists are aware that he does not adopt the view that they are gymnospermous. We may soon expect, in the Prodromus, the full presentation of this view.

A separate little sheet contains characters, given in advance, of a few new *Coniferæ:* among them a Larch of N.W. America, *Larix Lyallii*, remarkable for a cobwebby woolliness of the young shoots and leaf-buds,

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the scales of the latter with a fringed margin. We have from the same author his

Considérations sur le Méthode Naturelle en Botanique. 8vo pamph. Florence, 1863.—A good historical view of the development of the natural method, with some pertinent illustrations of the obvious importance in all the divisions, from highest to lowest, of looking to *types* and the *ensemble* of characters rather than resting upon single points,—in other words, of carrying the spirit of the natural rather than of artificial systems throughout the whole domain of botany. A. G.

3. *Tree-labels for the Arboretum.*—Mr. J. H. Creighton, of Chilicothe, Ohio, who is forming, with rare and thoughtful generosity, an extensive arboretum for a college in Ohio, has contrived a plan of permanent label for the trees, which is worthy of general adoption in public grounds and parks. The label is of cast iron; and it exhibits in capital letters, in bold relief, the scientific and the popular name of the tree. Having the pattern and a stock of letters prepared for his own use, Mr. Creighton offers to cast, at a low rate, any number of labels, with any desired name.

A. G.

4. *Ozone produced by Plants.*—Professor Daubeny of Oxford has contributed to the Journal of the Chemical Society, for January last, an interesting article, giving the details of a series of careful experiments, which go to prove that green foliage, in assimilating carbonic acid, water, &c., liberates a part of the oxygen in the form of ozone. After his experiments were made, Dr. Daubeny found that Kosmann of Strasburg had reached the same conclusion, but through less refined experiments. Referring to the first paper he ever communicated to a scientific society, that published in the Philosophical Transactions for 1834, on the evolution of oxygen gas by plants in the day-time, Dr. Daubeny concludes: "Should I now have established to the satisfaction of the scientific world, that these same green parts of plants, at the very time they are emitting oxygen, convert a portion of it into ozone, I might hope that these researches of my later years will serve appropriately to wind up those undertaken in my younger ones, by showing that vegetable life acts as the appointed instrument for counteracting the injurious effects of the animal creation upon the air we breathe, not merely by restoring to it the oxygen which the latter had consumed, but also by removing, through the agency of the ozone it generates, those noxious effluvia which are engendered by the various processes of putrefaction and decay,"—engendered, we may add, as much by decaying vegetable as by animal matter.

A. G.

5. *Morphology of Stamens, and use of Abortive Organs.*—In a recent number of the *Gardeners' Chronicle*, the editor, in giving a full account of *Dombeya angulata*,—a rare plant, which has just flowered at Kew,—describes as follows the morphology of the stamens, and the remarkable assistance which the *staminodia*, or barren stamens, seem to render as *go-betweens*, carrying pollen from the efficient stamens to the stigmas.

"The stamens in this plant, as in all the Malvales, may be looked upon as compound: while the ordinary stamen corresponds to a simple leaf, the groups of stamens in the Mallows and allied orders may be regarded as the equivalents of compound leaves, united together at their bases.

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Some of the lobes or leaflets of these compound leaves bear anthers, while others are destitute of anthers, and constitute the barren stamens or staminodes. Some light is thrown on the uses of these barren stamens by an examination of the plant now under consideration. In the fully expanded flower, the inner surface of the upper angle or point of each petal is about on a level with the stigma and with the tip of the barren stamen, the outer flat surface of which latter, as well as the adjacent portion of the petal, are often dusted over with pollen, the true stamens nevertheless being at a considerable distance beneath these organs. In less fully developed flowers the barren stamens may be seen curving downwards and outwards so as to come in contact with the shorter fertile stamens, whose anthers open outwardly, and thus allow their contents to adhere to the barren stamens. These latter, provided with their freight of pollen, uncoil themselves, assume more or less of an erect position, and thus bring their points on a level with the stigma, whose curling lobes twist round them and receive the pollen from them. The use, then, of the long staminodes seems to be to convey pollen from the short fertile stamens to the stigma, which, but for their intervention, could not be influenced by it. The presence of pollen on the upper and inner corner of the petals is readily explained by the fact that owing to their position and peculiar form they all come in contact with the ends of the staminodes and the stigmas, and hence they too get dusted with pollen.

"These arrangements would therefore seem to favor self-fertilization; and they show how an organ spoken of sometimes somewhat contemptuously, as barren, rudimentary, imperfect, or the like, may yet play an important part, both in the architectural plan of the flower, and in its life-history."

We venture to suggest that, although this curious arrangement may serve to ensure a certain amount of self-fertilization, yet it must likewise be studied in relation to the action of insects which probably visit these flowers, and, we fancy, may have something to do either in the deposition or in the removal of this pollen, so bringing about cross-fertilization.

In regard to the stamineal structure, briefly sketched in the beginning of the above extract, we would remark that, if we mistake not, Duchartre should have the credit of having brought to view this structure of the malvaceous andrœcium more than twenty years ago; that the inferences from organogeny soon after found a striking illustration in this country in the genus *Sidalcea;* and, finally, we are gratified to perceive that a theoretical view which has in this country been set forth as a part of elementary botany for many years (see Bot. Text Book, third edition, 1850, p. 249–252), is now making its way in England. It is evident that the name (*deduplication*), and the fanciful or *un*-morphological conceptions, with which this sort of multiplication of organs (in which a pair or a group occupy the place of one) was originally associated, have prejudiced British botanists against the *thing;* and it was on this account that we preferred the unobjectionable name of chorisis,—defining it in the terms of the above parenthesis, and illustrating it, in the class of cases in question, by the comparison of such compound stamen with a compound leaf. In another class of cases, anteposed parts are likened to intrafoliaceous stipules. A. G.

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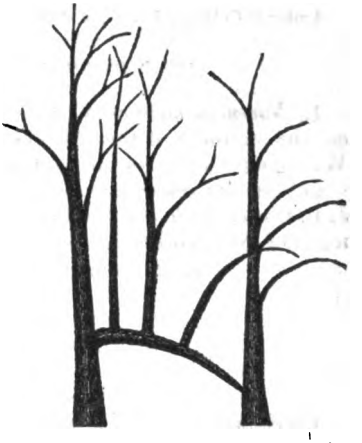
6. *Remarkable union of two trees;* by PAYSON W. LYMAN.—Near the village of North Chester, in Hampden Co., Mass., there stands a remarkable elm tree (*Ulmus Americana*), of which the annexed sketch will give a tolerably accurate idea. It stands near the summit of a range of hills, on the eastern bank of a branch of the Westfield River, in a narrow ravine, on either side of which wooded hills rise abruptly. It is considerably exposed to the light, being near the edge of the woodland.



The two parts of the tree, which rise from the ground and support the arch, are 30 feet apart, the one on the left of the sketch being as much as 2½ feet in diameter, and rising to a height of nearly or quite 100 feet, while that on the right is 1¾ feet in diameter, and not so high. The arch springs from the tree on the left at the height of 14 feet, and connects with that on the right at the height of 4 feet. Its diameter, near its junction with the former, is fully 1½ feet, gradually diminishing in size toward its junction with the latter, where its diameter is about 6 inches.

Its union is equally perfect at either end, though its connection seems to be more natural and regular at its larger extremity; which would lead one to suppose that, in some way, a branch of the tree on the left had been bent over and become engrafted into that on the right. The probability of this supposition is enhanced by the statement of the gentleman who owned the land forty years ago, that the tree then stood on the line of a fence, and that he, noticing the arch, supposed that it had been bent over to form part of the fence. He further states that, if he remembers correctly, the branch now forming the arch then extended beyond the tree with which it has united.

The arch runs lengthwise of the ravine, and, together with the trunks which rise from it, derives its nourishment from both sets of roots. Of these three intermediate trunks, that on the left is 14 inches in diameter, and attains an altitude equal to that of the main trunk on the left of it. The diameter of the second is 11 inches, and of the third 6 inches, the two rising to a height proportioned to their size. By a rough estimate it would appear that the horizontal branch supports a weight in addition to its own of about 4400 pounds. About midway between the two original trees, there rises a beech tree (*Fagus ferruginea*), which divides before reaching the arch, which it includes within its branches, but does not in any place come in contact with or support it.

A person desiring to see this remarkable tree would need to go about a half-mile north of the village of North Chester, to a saw-mill, where he would cross to the east side of the stream, traverse the fields, and climb the hill, following a little ravine for a distance of forty or fifty rods to the edge of the woodland, where he would readily discover the tree.

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It is somewhat difficult of access, but would repay any one interested in objects of this kind for the trouble required to reach it. It has been known more or less to individuals in its vicinity for forty years at least, but has never attracted very wide attention.

Amherst College, Jan. 15th, 1867.

IV. ASTRONOMY AND METEOROLOGY.

1. *November meteors in* 1866.—Accounts of the grand meteoric shower on the morning of the 13th–14th of November continue to reach us. We compile the following summary.

(*a.*) *In the Sandwich Islands* (W. long. 158°, N. lat. 21° 15′).—Mr. J. P. Cooke, with seven others, saw 317 meteors in five hours on the night of Nov. 13th–14th, 1866.

From 10^h to 11^h	P.M.,	22	meteors.	Sky clear.
" 11 " 12	"	44	"	Cloudy in N.E.
" 12 " 1	A.M.,	47	"	Sky half covered.
" 1 " 2	"	63	"	Clear.
" 2 " 3	"	141	"	Clear.
Total in five hours,		317	"	

There was no special radiation from Leo. A few brilliant meteors were observed between 3^h and 4^h A.M., but they were not as numerous as between 2 and 3 o'clock. No count of them was kept however.

These observations serve as a continuation of those in the United States, and show that there was no revival of the shower directly after our dawn.

(*b.*) *Asia Minor.*—Rev. A. T. Pratt, M.D., in a letter from Marash, Turkey, gives the following account of the shower as seen at that place.

"After midnight, we did not look out till 2^h 45^m A.M., when they were decidedly frequent. Miss Spencer, who is living with us, being called, we went out and took our station to count them, with result as follows:

	N.W.	S.W.	Total.
From 3^h 0^m to 3^h 15^m,	200	298	498
" 3 15 " 3 30	300	566	866
" 3 30 " 3 45	486	662	1,148

"They were so numerous after this as to make it impossible to count them; falling by dozens and scores at a time till about 4^h 30^m, when from 4^h 30^m to 4^h 40^m, in the southwest, were counted 200,—the number having sensibly decreased,—when we were compelled to leave the field.

"All the meteors radiated from the same *space* in the heavens (hardly the same point), i. e., that between γ and ϵ Leonis, and passed thence in every direction, only two or three being observed which did not conform to this law."

(*c.*) *In India.*—Rev. Wm. Wood, in a letter to his son from Ahmednuggur (N. lat. 19° 5′, E. long. 74° 55′), says that he watched all the night of the 13th–14th, and that a good many meteors fell before midnight, and so on till three o'clock, but that from that time till light there was a shower of them. At one time he counted 100 in five minutes.*

* It is not certain, however, whether these were seen by one or by five persons.

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One meteor left a train which moved *westward*, being visible for five minutes.

(*d.*) *In India.*—Rev. Edward Chester, writing from Dindigul (N. lat. 10° 25′, E. lon. 78°), says: "For a few moments I began to count the meteors, but they came so thick and so many at a time that I had to give it up. I saw thousands. I saw nothing else from 4 o'clock until daybreak, and even saw some within fifteen minutes of sunrise."

(*e.*) *In the N. Atlantic.*—Mr. E. Guillemin,* at sea 45 miles N.E. of Flores, saw the meteors cross the sky from E. to W., with long trains. A narrow cloud 10° high lay along the horizon. From behind it, from a point N. 59° E., luminous trains shot across the sky. The parallel paths were projected into the meridians of a sphere, the point of divergence being the pole. Those which were near the horizon were shorter and more like the ordinary shooting stars. Toward the zenith, however, they were much more brilliant, and their time of flight longer. Those which crossed the zenith rose perpendicularly from the eastern horizon, and leaving behind an immense phosphorescent arc, disappeared low in the west. From 10^h to 11^h the stars appeared either isolated or in groups of two and three, at intervals of from four to twenty seconds. They moved with uniform velocity, and had a mean duration of flight of seven or eight seconds. After 11 o'clock the display gradually diminished, and ended about half past three in the morning.

(*f.*) *At Cape of Good Hope.*—Mr. G. W. H. Maclear reports (Astron. Monthly Notices) between 10^h P.M. and 13^h A.M. 33 meteors seen at the Cape of Good Hope. Between $13^h\ 3^m$ and $16^h\ 21^m$ A.M. they saw 2742. Of these there were 1774 between $13^h\ 51^m$ and $14^h\ 36^m\ 45^s$, that is, in about three-fourths of an hour. The number of observers is not stated.

(*g.*) *Eastern Asia.*—There appears to have been no remarkable display at Shanghai, and at Yokuhama in Japan a watch kept that night detected nothing unusual.

(*h.*) *At Athens.*—Dr. J. F. J. Schmidt deduces hourly numbers for one observer for the twelve hours from 6^h P.M. to 6^h A.M. from observations made at Athens. There were different persons actually counting during the separate hours, but allowances are made for personal peculiarities. During the two critical hours, 2^h to 4^h A.M., no direct count was kept up. The following are the numbers:

6	6	133	785 (!)
6	7	980	405
6	50	1055 (!)	125

Total in the 12 hours, 3564 meteors.

(*j.*) Throughout the continent of Europe the shower was observed, and it maintained everywhere the same general character, no differences being noted that may not be due to personal peculiarities or to the weather. In Paris and Rome the weather was unfavorable.

Mr. A. Quetelet, at Brussels, locates the radiant at R.A. 148°, N. Dec. 24°. The time of the maximum was, he thinks, about a quarter past one o'clock.

(*k.*) *In Great Britain.*—At Edinburgh one observer saw the following numbers in successive minutes from $12^h\ 58^m$ to $1^h\ 38^m$ (G. m. time),

* Comptes Rendus, lxiii, 961. Compare this vol., p. 88, No. 25.

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another person keeping the record. The sums of the columns give the numbers for each five minutes.

28	30	38	40	44	33
30	36	29	35	31	30
32	34	30	35	30	23
60	64	40	52	29	23
60	38	41	50	29	23
210	202	178	212	163	132

During the next half hour were seen 395, making a total of 1492 for one observer in the hour. Similar records of numbers by other observers are given in the Astr. Soc. Notices.*

Sir John Herschel located the radiant at long. 142° 20′, lat. 10° 15′ N. Since this point is very nearly—perhaps exactly—90° from the sun, he concludes that the orbit of the meteors is very nearly circular and the motion retrograde. He adds (Astr. Soc. Notices, xxvii, 21), "How far this conclusion of a retrograde motion of the meteorites' revolution round the sun—a conclusion already, I believe, arrived at by Mr. Newton—is compatible with the truth of the 'nebular hypothesis,' we may leave it to the advocates of that hypothesis to consider."

A train observed by him remained visible six minutes, drifting slowly *southwards* over a space 8° or 9°, and at the same time changing its direction so that at its disappearance it was at right angles to its original position.

Mr. A. S. Herschel gives (Astron. Soc. Notices) the following determinations of the radiant. Most of them are from paths recorded by different observers upon charts of the British Association.

Long.	N. Lat.	Long.	N. Lat.	Long.	N. Lat.
141° 6′	10° 5′	144° 45′	10° 4′	145° 40′	11° 52′
142 41	10 58	141 37	11 19	143 41	9 54·5
143 7	9 16	143 31	9 28	143 12	10 3
142 10	10 15	141 36	9 27	142 58	9 9
142 28	9 49	146 41	10 20	142 51	10 42

The magnets at Greenwich were remarkably quiet during the night. Prof. Challis remarked an unusual glow in the atmosphere during the display.

(*l.*) *Observations with the spectroscope.*—Mr. A. S. Herschel and Mr. John Browning were provided with spectroscopes arranged for direct vision. Mr. Browning says (Astron. Soc. Notices, 1867, p. 77):

"After catching a few spectra in different directions, I at length decided on keeping the direct-vision prism pointed a little to the west of Leo Major, with the axis of the prism parallel to the horizon. The spectra which I saw were those of meteors which started from the radiant point and passed through the belt of Orion. Of course the number of meteors which came into my field was comparatively limited, but the whole of them travelled in a direction parallel to the axis of the prism, a condition essential in the observation of the spectra.

"From the rapid flight of the meteors rendering the spectra very difficult to catch, I cannot pretend to speak with confidence of the appear-

* There is an important misprint in the 25th line, p. 87 of the last number of the Journal, in Dr. Gould's letter. For $12^h\ 39^m\ 0^s$, read $12^h\ 59^m\ 0^s$.

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ance of the spectra shown by the prism, but I saw a great difference between the spectra. I believe that I saw spectra of the following kinds:

"A. Continuous spectra, or those in which the whole of the colors of the solar spectrum were visible, excepting the violet rays.

"B. Spectra in which the yellow greatly preponderated; but which in every other respect resembled those above described.

"C. Spectra of almost purely homogeneous yellow light, but with a faint continuous spectrum, that is, a faint trace of red on one side and green on the opposite side of the yellow portion of the spectrum.

"D. Spectra of purely homogeneous green light; of this kind I only saw two.

"I observed through the prism spectra of several trains. The light which was mostly blue, green, or steel gray, generally appeared homogeneous; but this may have arisen from the light having been too faint to produce a visible spectrum. Stars below the second or third magnitude, although visible through the prism, fail from this cause to give spectra in which blue and red are perceptible."

As was indicated in the last number of the Journal (p. 88), the eastern limit of the shower must have been in Central Asia. It was a little east, however, of the line there given.

Several papers concerning the theory of the meteors by Schiaparelli, Faye, LeVerrier, Peters, &c., of which we had intended to give here an abstract, must be deferred to the next number of the Journal. H. A. N.

2. *New minor planet, Antiope*, (90).—Dr. Luther discovered a minor planet on the 1st of October, to which the name Antiope has been given.

3. *New minor planet*, (91).—The ninety-first minor planet was discovered by Mr. Stephan at Marseilles on the 4th of November.

4. *Comet.*—Mr. Stephan discovered a telescopic comet on the night of the 22d of January, in R.A. $2^h\ 34^m$, and N.P.D. 74° 26′.

5. *Aurora Borealis at Highland, Illinois;* by A. F. Bandelier. (From a letter to the editors, dated Highland, Madison Co., Ill., Nov. 11, 1866.)—I find in No. 119, 2d series of this Journal, (Sept. 1865,) observations on the aurora of Aug. 3, 1865, at your city, among which I notice some remarks on the change of color of auroral streamers, from white and yellow into a rosy hue; which the observer attributes to the effect of "*sunlight* striking the tops of those streamers at the height of several hundred miles—as it must have been at that hour—above the earth's surface." The learned author of the said communication calling the attention of auroral observers to this fact, I venture to transmit to him, through your kind intermediary, some extracts from my auroral note-book (kept since 1860, and containing new observations of 47 displays), bearing on the points alluded to by him.

1860, Aug. 12, 9·4 P. M.—A group of splendid streamers appeared N. 15° W., white at first, but turning into purple above.

1860, Sept. 6, 8·33 P. M.—A bluish glow, N. 30° W., issuing a cluster of red streamers; they shifted slowly toward Ursa Major, color turning from purple into an intensive bloody red.

10·5.—The entire upper border of the dark segment dissolved into a smoky cumulated mass, out of which a perfect sea of streamers is seen to issue. The streamers are white below, purple above, the most vivid red being always toward the middle of the streamer.

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10·25.—E. and W. the streamers incline toward the horizon, and assume the deepest red hue, while in the N. the color is much paler.

1861, March 9, 8·20 P. M.—The dark segment has completely vanished and a semicircle of streamers has taken its place. They reach as high as the pole-star, and assume a red hue above an altitude of 25°. The most beautiful color is at both the eastern and western extremities.

Observation made on Durham Terrace, Quebec, Aug. 7, 1862, in bright moonlight. Yellow streamers rose from N.E. to N.W., their base being at an altitude of 25°–28° and the tops reaching the zenith. . . . . These streamers appeared stationary, but the intensity of the light moved regularly through their feet from E. to W. and backward, also flowing upward along the streamer. (Same observation at 8·10 P. M. of Aug. 8, on St. Lawrence river, near Trois-Rivières, moon shining very brightly. Streamers of yellow hue.)

1862, Oct. 3.—Full moonlight and display rather indistinct on account of it. I noticed the sky to turn purple in the E. at a low altitude, and at the beginning of the aurora.

Feb. 20.—Near the moon there was a patch of pale carmine, of alternately increasing and decreasing intensity.

In general, I have never seen a single streamer that was not originally *white*, but turned sometimes into purple or bloody-red *upon reaching a certain altitude.* At the moment of issuing, the beam is white and brightest at its base; as it increases in size, it generally attains a motion along the horizon to the west, and also the intensity decreases below and appears greatest in the middle of the beam. When the beam has reached its most westerly position, then the base vanishes and the top appears brightest, the streamer appears as an isolated cloud of more or less brilliant light of varying intensity, until it begins to vanish.

When several arches or layers of auroral matter succeed each other and the tops of the streamers of one arch (still below our horizon) appear at their vanishing points behind the arch immediately preceding, we may sometimes notice the sky under an auroral arch in sight to turn purple also.

I have also noticed that the condition of the atmosphere has great influence on the color of auroral light. By hazy weather streamers appear red, nearer the horizon than by a clear transparent sky.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Analysis of a Meteoric Iron from Colorado;* by Dr. C. T. Jackson. (From a letter to one of the editors, dated Boston, Nov. 10, 1866.)—I received last Tuesday, Nov. 6th, a piece of meteoric iron from Rev. Mr. Thompson, who brought it from Colorado and who had negotiated for the large mass with the intention of presenting it to the Boston Society of Natural History. I have just learned that Prof. Shepard through the agency of a friend in Denver City has secured the original mass, said to be two feet in diameter, for his cabinet. It appears from Mr. Shepard's letter to me that it is the same mass that is mentioned in the last (Sept.) No. of your Journal, page 250. I made the chemical analysis of it before being aware it was the same meteorite described, and since no previ-

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ous analysis of it has been made, I offer mine to you for the Journal, Prof. Shepard expressing a desire that it should be published.

The piece of meteoric iron given me by Mr. Thompson, who brought it from Colorado, weighs four ounces. It has been heated in a forge fire in order to cut it more easily; but still the Widmannstättian figures come out, when dilute nitric acid is applied to the polished surface, as distinctly as possible and consist of a series of small nearly equilateral triangles with the lines well defined and quite elevated. On one side of the specimen was a crust about one-eighth of an inch thick, consisting of sulphid of iron. This probably in the unaltered meteorite is a bisulphid of iron mixed with oxyd of iron.

A portion of the clean metal sawed off from the mass has the sp. gr.= 7·692.

On chemical analysis by the most approved method, separating the iron from the nickel by succinate of ammonia and determining the nickel as oxyd of nickel and then analyzing this oxyd for cobalt and copper—a separate portion of the meteorite being employed in analysis for the tin which was twice determined, and the nitric solution being tested for phosphoric acid and sulphuric acid, &c.—the results per cent of my analysis are as follows:

Metallic iron,	90·650
" nickel,	7·867
" cobalt,	0·010
" tin,	0·020
Insoluble matter consisting of a little silica, schreibersite and chrome as proved by blowpipe investigation,	0·950
	99·497

2. *Hailstones in China;* by S. W. Williams.—On Tuesday at 6 P. M. on June 5, 1866, a thunder storm came from the northeast, and broke over Peking with great violence. The hailstones soon followed the first dash of rain, and increased in size and quantity till the rain almost seemed to cease. The shower lasted forty minutes, leaving the yards white with hailstones, but as the wind was light no damage was done. The very largest stones were 4 to 4½ inches in circumference; the prevailing shape was conical, and almost all the stones exhibited a kernel of clear ice enclosed in frozen snow, with a covering of ice outside. The strata of air through which they passed in their descent must have been of very different degrees of temperature to produce such distinct layers of ice and snow in the stones. Such hailstorms are not frequent in the North of China, and the people say that this one is the most remarkable since July, 1838, when the stones were like oranges and apples and melons for size, and did great damage to dwellings and trees.

3. *U. S. Coast Survey.*—The eminent mathematician, Prof. Pierce of Harvard, has been appointed to the office of Superintendent of the Coast Survey, left vacant by the death of Prof. Bache.

4. *Chicago Museum of Natural History.*—The late Major Kennicutt at the time of his death was Director of the Chicago Museum of Natural History, an institution of which he was essentially the founder. This office has recently been filled by the appointment of Mr. William Stimpson, one of the best zoologists of the country.

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OBITUARY.

Prof. BACHE.—The death of Professor ALEXANDER DALLAS BACHE, just announced, will awaken profound regret throughout a very large circle of scientific friends. For the last thirty years he has been intimately connected with the progress of American Science. In some important departments he, more than any other man, may be regarded as the leader.

He was graduated at the Military Academy at West Point, in 1825, holding the first rank in his class. He was immediately appointed Assistant Professor of Engineering in the Academy, and occupied the position for one year. After serving as an officer in the Corps of Engineers for three years, he resigned to accept the professorship of Natural Philosophy and Chemistry in the University of Pennsylvania, to which he was elected in 1827. After filling this place with distinguished success, for a number of years, he was called, in 1836, to the presidency of the Girard College, then recently established in Philadelphia by the princely bequest of Stephen Girard. Six years later he received and accepted the appointment of Superintendent of the United States Coast Survey, a post made vacant by the death of Professor Hassler. He entered upon this office in November, 1843. Since that time, a period of twenty-three years, the results of his labors have been public property. It would be out of place in this brief notice to speak of the magnitude or the importance of that great national work, the Coast Survey. It is proper to say, however, that few men could have carried to it such ample scientific preparation, so much practical wisdom, and such signal, almost unrivalled, administrative talents. His annual reports to Congress, growing in fulness and extent as the work advanced, form an invaluable series of scientific papers. They have justly won for him not only an American but a European reputation. It is well known that eminent scientists in Europe, engaged in the vast labors of geodesy undertaken by the different governments, have sought with eagerness for the Reports of the American Coast Survey, and have placed them, as regards accuracy and exhaustive thoroughness, in the first rank of works upon that subject.

He has contributed many memoirs to our scientific journals, and many to the American Association for the Advancement of Science, of which he was twice president, and always a leading member. These memoirs, often very elaborate, have generally been devoted to the discussion of original researches in the more progressive branches of physical inquiry, and are well worthy of attention not only as substantial contributions to science, but as models of research.

During his presidency of Girard College from 1836 to 1841, he spent a year abroad under the direction of the Board of Trustees, to examine and report upon the state of education in Europe. The results of this examination, executed with great care and minuteness of detail, were given to the public in a full and very instructive octavo volume in 1839.

On the establishment of the National Academy of Sciences, by the Act of Congress, in 1863, the members of that body, intended to represent and direct the highest science of the country, unanimously elected him their first president for a period of six years. Unhappily for the interests of science that period has been cut short. The disease which has now terminated fatally, induced perhaps by over mental action, has for many months been making inroads upon his fine physical constitution, and

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impairing the vigor of his large and well-balanced powers of mind. His friends have watched its progress with alternate hopes and fears, and have only recently yielded to the sad conviction that his allotted work was done.

In the administration of his office as Superintendent of the Coast Survey, Prof. Bache was always kind and considerate to his subordinates —but never blind to any remissness in duty. He was himself a great worker and he expected every body under him to follow his example.

In society he was eminently genial. No one knew better than he, how to throw off the care of business when a task was done, and give himself up to the mirth and merriment of the hour. To his friends he was most generous and obliging, and very many of them will feel his death as a sorrowful, personal bereavement. He leaves a devoted wife, who has been many years literally the sharer of his labors, to mourn her irreparable loss and bear the burden of solitude in the midst of society. A. C.

J. Burkhardt.—Mr. Burkhardt, long associated with Prof. Agassiz as his artist, died on the 20th of February last, from the effects of a disease consequent on exposure in the course of the late Brazilian expedition.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *First Annual Report on the Geology of Kansas;* by B. F. Mudge, A.M., Prof. of Geology and Nat. Hist. in the Kansas State Agricult. College, and State Geologist for 1864. Lawrence, 1866. 56 pp., 8vo.

Preliminary Report of the Geological Survey of Kansas; by G. C. Swallow, State Geologist. Lawrence, 1866. 198 pp., 8vo.

The first of these Reports gives the results of a reconnoissance made in 1864. It contains some facts of general interest to the people of Kansas, —especially in regard to the saline springs, and the manufacture of salt, but nothing new to science.

The second Report is a more important work. It contains the results of an examination of Eastern and Central Kansas, made in 1865, and includes the separate Reports of Dr. C. A. Logan on the sanitary relations of the State, that of Dr. T. Sinks on its Climatology, and the Report of the Assistant Geologist, Major F. Hawn.

A detailed section of the rocks of Eastern Kansas is first given, in which the classification of the Permian proposed by Swallow and Hawn is essentially retained. This makes the formation in that region about 700 feet in thickness, or nearly three times that admitted by Meek and Hayden (this Journal, [2], xxvii, 424). These geologists regarded the intermediate strata, which contain both Permian and Coal-measure fossils, as part of the Upper Coal-measures, resting conformably upon those below. In this Report these strata are considered as Permian; and it is claimed by Prof. Swallow that a want of conformability may be detected between them and the true Coal-measures, by comparing sections made at different localities. This question of conformability in the series is a very important one, and deserves further investigation.

According to this Report the oldest rocks in the State are Lower Carboniferous. The Coal-measures occupy the surface of Eastern Kansas over an area of 17,000 square miles, and dip beneath the Permian to

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the westward. They contain not less than 80 separate beds of limestone. No additional evidence appears to have been obtained in regard to the age of the gypsum-bearing strata immediately above the Permian, and none relating to the more recent formations.

The report contains a chapter on economical geology, which, with the separate Reports appended, furnishes much information of value to all interested in Kansas.

2. *First Annual Report of the Geological Survey of Iowa;* by C. A. White, M.D., State Geologist. 4 pp., 8vo. Des Moines, 1867.—This Report is merely a preliminary notice of the organization and commencement of the present survey during the past year. A brief Report by the State Chemist, Prof. Hinrichs, is appended.

3. *Report of the Progress of the Geological Survey of North Carolina*, 1866; by Prof. W. C. Kerr, State Geologist. 56 pp., 8vo. Raleigh, 1867.—A brief Report, containing some information on the geology of the State, but mainly interesting as showing that its geological exploration is begun again in good earnest.

4. *Geological Survey of Canada*, Sir Wm. E. Logan, Director. Report of Progress from 1863 to 1866. 322 pp., large 8vo. Ottawa, 1866.—This Report reached us too late for a notice in this place.

5. *On the Rock-Salt Deposit of Petit Anse, Louisiana Rock-Salt Company.* Report of the American Bureau of Mines. 36 pp., 4to, with maps.—This important report is based mainly on the investigations of Dr. C. A. Goessmann. Dr. Goessmann obtained for the composition of the salt of Petit Anse, chlorid of sodium 98·8823, sulphate of lime 0·7825, chlorid of magnesium 0·0030, chl. of calcium 0·0036, moisture 0·3286=100.

6. *Plane Problems in Elementary Geometry: or Problems on the Elementary Conic Sections, the Point, Straight line, and Circle;* by S. Edward Warren, C.E., Prof. of Descriptive Geometry, etc., in the Rensselaer Polytechnic Institute. 162 pp., 12mo, with a plate and numerous figures. New York, 1867 (John Wiley & Son).—This little volume is prepared by one who is master of his subject both theoretically and practically, and is an excellent manual for the student or artizan. It gives directions with regard to the use of drawing instruments, is clear and precise in its definitions and demonstrations, and very varied in its problems.

7. *The American Naturalist, a Popular illustrated Magazine of Natural History.* Vol. I, March, 1867, No. 1. 56 pp., 8vo. Salem, Essex Institute.—This first number of the monthly American Naturalist, announced in this volume, at page 136, sustains fully all that was promised. Among its illustrations are two plates, one, of the crater of Kilauea in 1864–5, and the other, of the structure of the Land Snails, with reference especially to those of New England.

8. *Description of Fossil Plants from the Chinese Coal-bearing rocks;* by J. S. Newberry, M.D., being Appendix No. 1 of Geological Researches in China, Mongolia and Japan, by Raphael Pumpelly. 5 pp., 8vo, with a plate. Smithsonian Contrib. to Knowledge, 1867.—The species are those referred to by Dr. Newberry in his paper in this Journal, vol. xlii, p. 151.

9. *Musée Teyler:* Catalogue systématique de la Collection Paléontologique, par T. C. Winkler. Quatrième Livraison. Harlem, 1865.—This is a continuation of the Catalogue noticed in vol. xli, at page 287.

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THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XXXI.—*On certain recent contributions to Astro-Meteorology;* by H. A. NEWTON.

1. *Radiant points, or radiant areas.*

FOR more than twenty years a Committee of the British Association for the Advancement of Science has annually made an extended report on *Observations of Luminous Meteors*, in which have been given in detail the times, paths, physical appearances, and other phenomena, of meteors seen during the years immediately preceding. No special effort has been made until recently, to elaborate this mass of material. R. P. Greg, Esq., of Manchester, assisted by Mr. A. S. Herschel, at last undertook the task of plotting the paths contained in the voluminous records. By this means they have determined between fifty and sixty radiants, for different periods of the year. Prof. E. Heis of Münster, has in like manner, from observations made by himself and his assistants during a period of twelve years, deduced a similar and, to a considerable extent a corresponding series of radiant points. The latter series is in the Monthly Notices of the Roy. Astro. Soc., xxiv, 213. Both series are in the Report of the British Association for 1864, and in the Proceedings of the British Meteorological Society for Jan. 18th, 1865. From the latter source we give the following table. The general results of Mr. Greg's investigations as regards *meteor showers* are thus summed up in the Report of the Committee on Luminous Meteors.

"They appear to endure for almost any period, from twenty-four hours to eight or possibly ten weeks, differing from one another in rich-

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Comparison of the epochs and positions of radiant-points of shooting stars, concluded independently by R. P. Greg, Esq., and Dr. E. Heis.

Reference No.	From observations contained in the Brit. Assoc. Catalogues, &c., 1845–63. (R. P. Greg.)					Observed at Munster, 1849–61. (E. Heis.)			
	Epochs in their order of commencement.	No. meteors mapped.	Distinctive numbers (Greg).	Position of radiant. Right Ascension.	Position of radiant. North Declination.	Distinctive letters.	Right Ascension.	North Declination.	Epochs to the nearest half-month.
				°	°		°	°	
1	Dec. 20–Jan. 30	20	ii	22	75	A_1	29	50	Jan. 1–15.
						A_2	15	63	Jan. 16–31.
2	Dec. 20–Jan. 30	13	ii *a*	5	85	N_1	285	84	Jan. 1–15.
						N_2	0	90	Jan. 16–31.
3	Dec. 21–Feb. 4	28	iii	68	17	AG_1			
4	Jan. 2–Jan. 3	52	i	234	51	K_2	235	52	Dec. 16–31.
						K_1	242	51	Jan. 1–15.
5	Jan. 2–Feb. 4	30	iv	133	40	‡ M_2	166	52	Jan. 16–31.
6	Jan. 5–Jan. 25	15	iv *a*	173	32	MG_1			
7	Feb. 4–Feb. 26	36	v	147	34	M_3	150	60	Feb. 1–14.
8	Feb. 7–Feb. 26	20	vi	136	70	M_4	130	63	Feb. 15–28.
9	Feb. 9–Feb. 17	13	vii	76	40	A_3	65	51	Feb. 1–14.
						A_4	91	37	Feb. 15–28.
10	Feb. 10–Mar. 17	21	viii	168	9	S_1	170	11	" "
						S_2	178	7	Mar. 1–15.
						S_3	173	23	Mar. 16–31.
11	Feb. 11–Mar. 16	10	viii *a*	37	1	SG_1			
12	Feb. 19–Feb. 26	10	vi *a*	220	84	N_3	0	90	Feb. 1–14.
						N_4	250	83	Feb. 15–28.
13	Mar. 3–Mar. 27	11	xiii	44	72	N_5	340	80	Mar. 1–15.
14	Mar. 3–Mar. 31	30	ix	145	67	M_5	125	52	" "
						M_6	140	50	Mar. 16–31.
15	Mar. 3–Mar. 31	18	x	186	58	‡ M_2	140	50	" "
16	Mar. 12–Mar. 20	20	xii	223	39	MG_2			
17	Apr. 1–June 2	52	xi	194	52	M_7	160	53	Apr. 1–15.
						M_8	150	61	Apr. 16–30.
18	Apr. 2–May 1	20	xiv	189	4	S_4	194	5	" "
19	Apr. 8–May 28	20	xix	227	−8	SG_2			
20	Apr. 12–Apr. 13	17	xvi	276	26	QG			
21	Apr. 16–May 3	30	xv	96	87	N_3	265	83	Apr. 16–30.
22	Apr. 19–Apr. 20	25	xvii	282	33	DG_1			
23	Apr. 25–June 4	28	xviii	255	48	DG_2			
24	Apr. 30–June 4	15	xx	243	20	Q_1	218	20	May 1–31.
25	May 9–June 3	16	xviii *a*	277	42	D			
26	May 9–June 4	8	xxi	286	21	W	292	15	June 1–30.
27	May 29–June 17	18	xxii	336	45	B_1	332	60	May 1–31.
						B_2	333	42	June 1–30.
28	June 1–June 30	9	xx *a*	236	30	Q_2	242	12	" "
29	June 1–June 30	12	xxiii	300	85	N_9	290	80	May 1–31.
						N_{10}	150	83	June 1–30.
30	July 2–July 24	51	xxiv	291	53	B_3	315	54	July 1–15.
				to 313	43				
31	July 10–Aug. 6	26	xxvii	257	13	Q_3	262	12	July 1–15.
32	July 20–Aug. 4	46	xxv	359	70	N_{11}	20	85	" "
						N_6	337	86	July 16 to Aug. 15.
33	July 22–Aug. 10	70	xxvi	344	12	T_1	314	15	Aug. 16–31.
				to 327	10				
34	July 29–Aug. 22	123	xxiv *a*	302	44	B_4	306	59	Aug. 16–31.
				to 288	42	B_5	302	65	July 16 to Aug. 15.
				and 298	58				

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TABLE—continued.

Reference No.	From observations contained in the Brit. Assoc. Catalogues, &c., 1845-63. (R. P. Greg.)					Observed at Munster, 1849-61. (E. Heis.)			
	Epochs in their order of commencement.	No. meteors mapped.	Distinctive numbers (Greg).	Position of radiant. Right Ascension.	Position of radiant. North Declination.	Distinctive letters.	Right Ascension.	North Declination.	Epochs to the nearest half-month.
				°	°		°	°	
35	Aug. 6–Sept. 10	80	xxix	0	90	N_{12}	295	79	Aug. 16–31.
						N_{13}	130	84	Sept. 1–15.
36	Aug. 7–Aug. 16	...	xxviii	45	55	A_0	50	51	July 16 to Aug. 15.*
				to 20	62				
37	Aug. 17–Sept. 12	9	xxvii *a*	245	5	Q_2	262	12	July 1–15.
				to 262	12				
38	Aug. 17–Sept. 30	18	xxiv *b* *or* xxx *a*	282	42	B_5	293	57	Sept. 1–15.
39	Aug. 17–Sept. 30	150	xxx	333	50	EG			
				i.e. 314	52	E	330	50	Oct. 16–31.
				to 347	47	A_{11}	35	63	Sept. 1–15.
				and 333	41	A_{12}	44	63	Sept. 16–30.
				to 333	62	A_{13}	51	61	Oct. 1–15.
40	Aug. 18–Sept. 29	27	xxxi *or* xxx *b*	13	34	R_1	53	35	Sept. 1–15.
						R_2	46	37	Sept. 16–30.
41	Aug. 22–Nov. 5	27	xxxii	1	15	T_2	343	10	Sept. 1–15.
						T_3	1	11	Sept. 16–30.
						T_4	3	11	Oct. 1–15.
42	Sept. 6–Nov. 23	18	xxxiv	22	−9	TG			
						U	10	−11	Oct. 16–31.
43	Sept. 20–Oct. 11	35	xxxv	33	48	AG_2			
44	Sept. 25–Oct. 10	16	xxxvi	51	84	N_{14}	65	84	Sept. 16–30.
45	Sept. 27–Nov. 2	67	xxxiii	14	58	A_{14}	20	42	Oct. 16–31.*
						A_{15}	25	40	Dec. 1–15.*
46	Oct. 3–Oct. 20	11	xxxvii	140	45	LG			
						† L_1	115	55	Dec. 1–15.*
47	Oct. 4–Nov. 10	35	xxxviii	45	33	R_3	45	32	Oct. 1–15.
48	Oct. 18–Nov. 3	30	xxxix	33	12	O			
49	Oct. 20–Nov. 21	33	xl	91	56	F	75	40	Oct. 16–31.*
50	Oct. 31–Dec. 9	14	xliii	139	7	LH			
51	Nov. 1–Nov. 23	75	xli	16	49	AG_3			
52	Nov. 7–Nov. 15	...	xlii	153	22	L_0	150	28	Nov. 1–30.*
53	Nov. 23–Dec. 9	9	xlv	279	56	DG_2			
54	Nov. 24–Dec. 10	37	xliv	59	58	A_{16}	37	59	Dec. 16–31.
55	Nov. 26–Dec. 30	84	xlvii	96	36	G			
						† L_1	115	55	Dec. 1–15.*
56	Nov. 27–Dec. 19	10	xlvi	157	71	KG			

Total meteors, 1746; days, 1655; meteor-showers, 56.

(*) Radiants marked thus are extracted from the work by Dr. Heis, entitled 'Die Periodische Sternschnuppen.' (4to. Cöln, 1849.)

ness or intensity of display. In some there appears to be a tendency to maximum display on particular days, as for example xlvii, lasting from November 26th, to December 30th; but the most abundant display occurs from December 9th to 13th. In others no such maximum can be perceived. Their number, of fully fifty as yet ascertained, will probably not be much exceeded, unless by short-lived showers, and by others whose radiants culminate just before dawn. There is no confusion or

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chance in their return, but, on the contrary, the showers are very regularly recurrent every year, and, allowing a *radiant-region* of 10° to 15° in diameter for each, the so-called "sporadic" meteors will become extremely scarce, now that the principal showers and their radiants have been pointed out. A well-marked instance of long persistence and remarkable for having its radiant very small and fixed, is the shower of August 6th to September 10th, No. xxix. The great majority have, at the present time, been as clearly defined (as regards the time of their occurrence, duration, and positions of their radiants) as in the case with the older and better known showers of August and November. On the average of many years, the radiant-regions of a few are, however, still very extensive. In all, a plane, oval, or double-headed region of radiation appears to represent the conditions of the showers more correctly than a point. This elongation of the radiant-region is in most cases perpendicular to the ecliptic, or parallel to the *via lactea*, in or near which the greater number of the radiants in the latter half of the year are placed. The meteors of particular showers vary in their distinctive characters, some being larger and brighter than others, some whiter, some more ruddy than others; some swifter, and drawing after them more persistent trains than those of other showers. Their connection with the epochs and directions of large meteors still remains to be established."

From a private letter by Mr. Greg to Mr. B. V. Marsh we learn that some minor changes are found neccessary, by further observation and investigation, in the duration of the showers and the places of the radiants. Mr. Greg's charts containing the paths of nearly 2000 shooting stars are about to be published by the British Association. We may hope to receive them within a few months. We evidently need these charts in order to discuss intelligently this important subject. While waiting for them, however, one or two remarks may not be out of place.

That the so-called *sporadic* shooting stars should belong largely to rings or streams, as do the August and November meteors, is in the present state of our knowledge probable, or at the least is not improbable. The reasonings of Mr. Schiaparelli, which will be spoken of further on in this article, strengthens this probability.

But we meet with some difficulty in accepting the proposition that a ring or stream may be of such breadth as to require eight or ten weeks for the earth to traverse it, that is, that the ring may extend 60° or 70° along the ecliptic; or rather, if there were so broad a ring or stream, it would not appear to have a radiant area so small, and so well marked, as to be detected.

The position of the radiant indicates that point of the heavens from which the *relative* motion of the meteoroids with reference to the earth is directed. This direction is the resultant of two *absolute* motions, that of the meteoroids and that of the earth. If either of these should change, the place of the radiant will change.

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But during these eight or ten weeks the direction of the earth's motion would change 60° or 70°. If the direction of the meteoroids' motions were supposed parallel throughout the breadth of the stream, yet this change in the direction of the earth's motion alone appears to necessitate a change of the position of the radiant by a distance on the heavens of not less than 30° or 40°.

But for a group of such thickness, we can hardly suppose the absolute motions of the meteoroid parallel throughout its breadth. Each meteoroid must move about the sun in its own orbit, and though this is not entirely inconsistent with a parallelism of the paths where the group crosses the ecliptic, yet such a case is extremely improbable. Again it appears necessary that a meteoroid which is now on one side of the stream should be after half a revolution on the opposite side. Hence, we might reasonably expect that at the center of the stream we should find their paths crossing each other at large angles,—angles comparable in magnitude to the 60° or 70° which measures on the ecliptic the breadth of the stream. Such divergence of directions of the individual members of the group, would make the existence of an apparant radiant of moderate area impossible.

Again a stream whose thickness is so great, may be expected to have also large breadth in direction of the radius vector. This again would make the parellelism of the paths, and consequently the apparent radiation improbable.

In fact a ring of such enormous thickness as to require two months for the earth to cross it, would seem not only to lose all the essential characteristics of a distinct group, but also to be unable to manifest its existence by a constant and small radiant area.

The conclusions of Mr. Greg and Dr. Heis, are derived almost entirely from meteors seen in evening hours. But the phenomenon of radiation caused by parallelism of absolute motions should be more distinctly evident as the radiant is nearer the meridian. This occurs, in general, in the morning hours.

While, then, the existence of rings or streams is *a priori* probable, and so the existence of radiants for *very short* periods is to be looked for, yet the series now proposed will doubtless undergo essential changes, as we accumulate observations, or else some other cause than ring-formations be found to account for the radiation.

There should, in any case, be a tendency to a radiation, both from the zenith and from the point to which the earth is moving; hence from the region lying between these points, i. e., from the N.E. quarter of the heavens.

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2. *Influence of the August and November meteors upon the temperature of the atmosphere.*

Erman early asserted the existence of cold periods, from the 5th to the 12th of February, and from 10th to the 13th of May. These he attributed to the influence of the August and November meteors, assuming that they passed at those epochs between the earth and the sun. To the same cause he attributed certain dark days, and other appearances, said to have occurred in the years, A.D. 1106, 1206, 1208, 1706, and 1547.

In a series of papers read before the Paris Academy of Sciences, and published in the Comptes Rendus,* Mr. Ch. St. Claire Deville has given the results of an elaborate investigation of the alleged abnormal changes of temperature in these months, as well as those alleged for corresponding days of August and November.

Mr. Faye in response to the first of these papers, shows conclusively that the dark days, &c., adduced by Erman, cannot be referred with any probability to the meteors as their cause.

In his earlier papers, Mr. St. Claire Deville undertakes to show that there are periodic variations of the temperature of the critical days in February, May, August, and November, that correspond to secular maxima and minima of the August and November meteors. For the August meteors he assumes a maximum in 1847 or 1848, relying upon the assertion of Mr. Coulvier-Gravier.

The existence of a maximum for the meteors in or near those years, is in itself exceedingly doubtful, and the evidence adduced by Mr. Deville to prove corresponding changes of temperature, is also very far from satisfactory.

Mr. Deville's own conclusions, as given in his later papers themselves throw doubt upon the existence of any important connection between the meteors and the temperature of the air. He finds that there is an accordance, between the movements of the thermometer in the several months, February, May, August, and November; and that the 12*th day* of each of these months is the critical day of a marked inflection. But this accordance (*or solidarity*) between the several months is entirely lost when the days are so combined as to compare not the days of the same name in the month, but those corresponding to points 90° apart on the ecliptic. But in what possible way can the meteors create oscillations in the temperature of the atmosphere, whose maxima and minima, shall in November be one or two days *before* we reach them, shall in May be at the time of the passage of the earth across the plane of the November group, in Au-

*. Vol. lx, 577, 655, 696, 909; lxi, 5, 61, 350; lxii, 1054, 1149, 1209, and lxiii, 1030.

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gust shall be one or two days *after* the shower, and in February five or six days *after* the earth crosses the plane of the August ring?

3. *The paths and probable origin of Shooting Stars.*

The most important recent contribution to the theory of shooting stars is by Mr. Schiaparelli of the Brera Observatory at Milan. It is contained in a series of five letters to P. Secchi, published in the Bullettino Meteorologico of Rome.*

By a course of reasoning similar to that which led the writer to the same conclusion,† he argues that the mean velocity of the meteoroids, is considerably greater than that of the earth in its orbit. Hence their orbits are in general, long ellipses, or parabolas.

Assuming then (which is not improbable) that the meteoroids form in the planetary spaces a multitude of currents, or continuous rings, having all possible inclinations to the ecliptic, he proceeds to inquire in what way so singular a form of grouping of cosmical matter, could have been produced.

Notwithstanding the uncertainty of the determinations of the velocity of the solar system and of the stars in space, he considers it reasonable to assume that the velocities relative to the sun of the various bodies which are scattered through stellar spaces, are comparable in magnitude to those of the planets in their orbits.

Suppose now one of these bodies, a comet for instance, to come by its proper motion so near to the sun, that solar attraction far exceeds the attraction of the stars, and yet to be at such a distance that its annual parallax is but a few seconds. Its orbit about the sun will then be a conic section. Suppose now the sun to be at rest, and regard the relative velocity of the comet as the real velocity. Let fall a perpendicular from the sun upon the direction of the comet's motion. The area described about the sun in a unit of time, will be equal to one-half the product of this perpendicular into the comet's velocity.

As, however, the velocity is, in general, comparable in magnitude to the planetary velocities, and the perpendicular is in general, enormously greater than the distances of the planets from the sun, it follows that the areas described in a unit of time are, in general, very much larger than corresponding planetary areas. But these areas are as the parameters of their corresponding orbits. Hence, in general, the orbits of such comets would have enormous dimensions in every direction, and the bodies themselves would remain invisible to us, because of their great distance from the earth.

* Vol. v, Nos. 8, 10, 11, 12, and vol. vi, No. 2.

† This Journal, xxxix, 205–7, and Mem. Nat. Acad. of Sciences, vol. i, p. 309–311.

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In two cases only would they come within our field of vision. When the perpendicular is very small, a hyperbolic orbit would result, differing in general not much from a right line. As the radius of the sphere of our vision is only about four times the distance from the earth to the sun, this case would rarely happen.

The second case is when the relative motion of the comet is very small, that is, when the comet and sun are moving in nearly parallel paths, with nearly equal velocities. An orbit very nearly a parabola would result. This case would likewise be very rare, since of all possible velocities of the bodies in the stellar spaces, very few would be nearly equal and parallel to that of the sun.

The parabolic form of the cometary orbits should not then surprise us. This is not the only possible form. On the contrary it is one that is very rare. But owing to the nature of comets, and to our feeble powers of vision, we can see only those which describe just these orbits. Nor is there reason for wonder that the planes of their orbits have no relation to the plane of the ecliptic.

The characteristics peculiar to planets can be accounted for by their formation in the solar system; those peculiar to the orbits of comets depend on the manner in which the sun attracts them to itself from the depths of space. The latter then should have an origin foreign to our system. To which of these two classes belong the shooting stars? Are they planets, or are they comets?

The planetary hypothesis has hitherto been favored by astronomers. The ring theory, however, as Mr. Schiaparelli believes, leads to serious difficulties respecting the origin of the shooting stars, whether the rings be regarded as integral parts of the solar system from the beginning, or they be supposed to have come from space, being attracted hither by the sun.

There are two arguments which show that the meteoroids should be classed with the comets as originally strangers to our system, rather than with the planets. The first is that their orbits seem to be inclined at all angles to the ecliptic;* the second, that their velocity requires a long if not a parabolic orbit.

* That the inclinations of the orbits of the meteoroids are of all magnitudes, Mr. Schiaparelli infers, principally, from the positions of the radiants given by Messrs. Greg, Herschel, and Heis. Although these radiants are open to criticism, yet the above conclusion is undoubtedly true. It is readily seen that if the orbits of the meteoroids are but little inclined to the earth's orbit, the apparent paths of the meteors should themselves rarely be seen to cut the ecliptic, and that the paths produced forward should rarely cut the ecliptic above the horizon. In other words, the paths as seen in the sky should, with rare exceptions, appear to lead away from that circle. So far as my own observation is concerned, I find no such regularity. The meteors go toward the ecliptic as often as from it. Apparent radiation from points of such considerable latitude as those given in the table on pp. 286, 287, shows also that many of the orbits of the meteoroids, at least, are inclined at large angles to the earth's orbit.

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Admit, then, that the shooting stars come from stellar space, and we have no longer closed rings of short period, but streams of a parabolic form, for which the period of revolution, if there is one, is very great. Now this parabolic current, which at first seems so strange a form, is not only possible, but it is the *only* form in which a cosmical cloud drawn from stellar space by solar attraction can approach the sun and become visible to us.

To prove this, he supposes a cosmic cloud of the size of the sun, to be at first at a distance equal to 20,000 (the mean distance from the earth to the sun being unity). The rarity of the matter in this cloud is regarded such that the mutual attraction of the particles may be disregarded. This cloud of particles is then supposed to have a velocity (relative to the sun) perpendicular to a line drawn to the sun, one twenty-thousandth of the mean velocity of the earth, or about one hundred yards a minute.

The several particles will move in elliptic orbits about the sun, but these ellipses will not be exactly equal. Mr. Schiaparelli shows that a cloud, of spherical form at first, would be deformed, little by little, and ultimately drawn out so as to have a very small transverse section. It will now lie along a parabolic arc, of which the sun is the focus. When the particle originally at the center of the globe reaches its perihelion, at a distance from the sun equal to $\frac{1}{2}$, the anterior portion of the group will have passed its perihelion 193·5 days, and have already crossed in its outward course the orbits of the minor planets. The end of the group will not have reached these orbits in its descent to the sun. The whole extends along 267° of anomaly on the parabolic orbit. The breadth of the group at its center, in direction of the radius vector, will be 96 meters, and in the direction perpendicular to the plane of the orbit, 37 kilometers. Its density at this place will be 400 millions of times the density of the original group.

If the primitive form of the group was other than spherical the same reasoning would apply, and similar results follow.

The apparent diameter of the assumed globe, as seen from the sun, is about 0″·1. But if the original cloud be supposed to have an apparent diameter of one minute, the resulting stream would require 636 years to pass the perihelion. Some of the nebulæ have apparent diameters exceeding that of the sun. A globe of such a size (1924″) would be transformed into a parabolic stream which would require more than 20,000 years to pass the perihelion. The cross section of this stream would be much greater than in the preceding case, but yet not so great but that the earth might cross it in a few hours, or at most, in one or two days. We may, then, without extravagant hypotheses account for the existence of meteoric currents which have been observed for hundreds or thousands of years, like that of August.

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For facility of reasoning, the original position of the supposed spherical group was placed at the aphelion of a long ellipse. But results similar in kind, and comparable in degree, would result, had the group been supposed at any point of a conic section of very great length.

If the orbit is an ellipse, the original form of the cloud would never be regained. At each perihelion passage, the length of the stream would be increased until it formed a closed circuit. The stream would be, at first, periodic, but finally constant. If the orbit is open, there would be a single passage only.

The supposed cloud was deemed to exert no sensible attraction upon its particles. To justify such an assumption, Mr. Schiaparelli makes an estimate of the density of the August ring. For the mean distance from each other, of the bodies of the August group, he obtains by computation about 100 (geographic) miles. This is obtained by quite arbitrary suppositions, but the result is very nearly that which is obtained by computations from the best data in our possession (see this Journal, xxxix, 207), combined with observations at Hartford in 1863, when six observers counted 153 different meteors in a half hour.*

For the size of the individual meteoroids, he assumes one gram, relying upon the conclusions of Mr. A. S. Herschel who compared the light of the meteors with the light of a candle, and hence inferred their weight. The estimate seems too small, for some of the trains fill cubic miles of space with matter of sufficient consistency to form a cloud visible for minutes (see this vol., p. 86). Yet the probable size of these bodies is so small that Mr. Schiaparelli's reasoning is still conclusive.

To each sphere whose radius is fifty miles he assigns, therefore, one gram of matter. The cloud first supposed had only $\frac{1}{355,555,333}$ the density of the resultant stream at the perihelion. Suppose, however, the space originally occupied by the meteoroids of the August stream, to be only one million times that now filled at the place where the earth traverses it. To each gram of matter would originally have belonged, in that case, a volume equal to that of a sphere 10,000 miles in diameter.

He then shows that a spherical group of bodies, each body weighing one gram, whatever be the dimensions of the group, must have at a distance from the sun equal to the earth's mean distance, a density such that the mutual distances of the members shall be less than 1·86 meters (2 yards), in order that the attraction of the sun shall not dissolve the group. If the mutual distances of the members exceed $1{\cdot}86^{m}$, the sun acts to separate the individuals from each other, not at the surface simply, but throughout the whole extent of the system.

* The corresponding mean distance from each other of the members of the November group, where we crossed it last year, is 30 or 40 miles:

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But if the mutual distances are, as before determined, 100 miles, the dissolving power of the sun is 10^{16} times the mutual attraction of the particles. In like manner, the dissolving power of the sun's attraction upon a group of similar bodies distant 20,000 from the sun, the mutual distance of the bodies being 10,000 miles, is 125,000,000 times the attraction which the group has for one of its particles. This latter force then may be safely neglected. The dissolution or deformation of the system must, moreover, begin much farther away from the sun than the assumed position of the cosmic cloud, out even in the stellar spaces. It can enter the solar system only as a parabolic current.

Even if we suppose a group that is tolerably dense, approaching the sun, as, for instance, a comet without a nucleus, there is a certain limiting distance within which the differences of solar attraction tend to dissolve it. If such a group passes this limit, in its descent to perihelion, the members will be scattered, and the original formation will never be restored. We have thus a most singular effect of attractive force, namely, the dispersion of a system that lacks coherence.

If now a dense cloud of bodies is supposed to pass near one of the larger planets, its orbit will be changed, and may become one of short period, like those of certain comets. If, moreover, its perihelion distance is less than the distance at which solar attraction disintegrates the groups, the cloud is dissolved into independent particles. Diversity of planetary perturbations produces in the orbits of these particles a variety of elements, especially variety in the periodic times. The group is gradually lengthened along the ellipse, and after a certain number of revolutions the cloud becomes a continuous ring. The meteors of November belong to such a group, while the ring is partially formed. The August meteors probably represent a group after it is transformed into a continuous ring.

Mr. Schiaparelli gives a summary of the consequences which result from the preceding discussions in the following propositions, which establish the basis for a new theory of falling stars.

"I. Matter is disseminated in celestial space in all possible grades of division. The first grade consists of the larger stars, either isolated, or collected in systems of few members. The second is made up of large agglomerations of small stars, the *star dust* of Herschel, into which many nebulæ are seen to be resolved by large telescopes. Then follow smaller bodies, which are invisible except when they approach the sun under the form of comets. Finally the last grade consists of cosmical clouds, composed of very minute elements, which have a weight comparable to that of objects which we are accustomed to handle or transport on the earth.

"II. This last class of bodies may have been formed in space, by the local concentration of the celestial matter, in a manner analogous to the crystallization of substances chemically dissolved in liquids. From what

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occurs in these crystallizations we are even led to think that such a form of aggregation is much more probable and more frequent than the others, which take place by large masses. Hence the volume occupied by the cosmical clouds may be a notable fraction of the stellar space.

"III. The movements of such clouds among the bodies of the universe, are comparable to those of the fixed stars, and are probably due to analogous causes. When any one of them enters the sphere of attraction of the sun, it cannot be visible to us unless its orbit relative to this great luminary is a very greatly elongated conic section.

"IV. Whatever may be the form and extent of a cosmical cloud, it cannot (with very rare exceptions) penetrate to the interior of the solar system, unless it has been transformed into a parabolic current, which may consume years, centuries, and myriads of years in passing, part by part, its perihelion, forming in space a river, whose transverse dimensions are very small with respect to its length. Of such currents, those which are encountered by the earth in its annual motion, are rendered visible to us under the form of showers of meteors diverging from a certain radiant.

"V. The number of meteoric currents crossing the spaces of the solar system, at all possible distances, and in all directions, is probably very great. The exceeding rarity of the matter contained in them, allows these currents to intersect mutually, without causing any disturbance to one another. They may undergo progressive transpositions and deformations in space, like rivers which slowly change their bed. They may be interrupted, and thence become double or multiple, and they may even in particular circumstances become closed elliptical rings. The November meteoroids are apparently portions of such a ring in process of formation.

"VI. The cosmical clouds having short periods of revolution around the sun, by which some are inclined to explain the appearance of shooting stars, cannot have a permanent existence without violating the known laws of universal gravitation.

"VII. The matter of the parabolic currents, after having passed the perihelion, returns into space in a state of dispersion, greater than that which it had before the passage. In particular cases, as when the current meets a planet, very great perturbations may ensue, and a separation of some of the meteoric stars into special orbits. Such stars from that moment may be called truly *sporadic*.

"VIII. Thus the meteoric stars, and other celestial products of analogous nature, which in past ages were commonly regarded as atmospheric phenomena, which Olbers and Laplace first ventured to make to come from the moon, and which at a later period were raised to the dignity of members of the planetary system, truly belong to the category of the fixed stars; and the name *falling stars* expresses simply and precisely the truth respecting them. These bodies have the same relation to comets, that the small planets between Mars and Jupiter have to the larger planets. The smallness of the mass is in each case compensated by the very great number.

"IX. Since we may safely regard it as certain that falling stars, bolides, and aërolites differ in nothing except their magnitude, we may conclude

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that the matter which has fallen from the sky is a fragment of that of which the stellar universe is formed. And as in such matter there is no chemical element that is not found upon the earth, the similarity of composition of all the visible bodies in the universe, already rendered probable by researches with the spectroscope, acquires a new argument for its credibility."

The further question is then broached, whether it is necessary for the original cloud to be made up of such small elements; whether, for example, it may not consist of a moderate number of comets. In such a case, we ought to meet, from time to time, with orbits somewhat unlike, which intersect each other in the depths of space, but which lose the characteristics of a common system, owing to considerable intervals between the times of perihelion passage.

The question is not a new one. Prof. Hoek of Utrecht has found several double and triple systems of comets,* which at a remote epoch were near each other in space, although their perihelion passages have differed by years. The most notable of these systems, is that of the comets 1860 III, 1863 I, 1863 VI, which at the end of the year 760, A. D., were at distances from the sun respectively 600·00, 600·42, and 600·25, and distant from each other 12·8, 16·3, and 8·1. To a spectator from the sun their apparent maximum distance was 1° 33′. Hoek believes that the comets of 1677, and of 1683, belong also to this system. The antecedent probability of a chance coincidence like that of these comets is exceedingly small.

We find thus analogies between the systems of shooting stars, and systems of comets. Can we not imagine mixed systems, in which a cloud of meteoroids are grouped in space about one or more larger nuclei, that is, about one or more comets?

If a system of this kind is drawn from solar attraction into the figure of a parabolic current, the parabola described by the principal body (or those described by the principal bodies) should evidently differ very little from the line along the center of the parabolic stream, consequently the preceding question is answered affirmatively whenever we find a meteoric current forming a parabola identical in magnitude and position with any parabolic cometary orbit. In such a case the comet will evidently form part of the current, and be one of its elements.

To test this question, Mr. Schiaparelli computed the following elements of the mean orbit of the August meteors, supposing it a parabola, assuming the radiant to be R. A. 44°, N. Dec. 56°, and the time of crossing the center of the group in 1866 to be Aug. 10·75. With these elements are placed those of the comet 1862 III, according to the latest determination of Dr. Oppolzer.†

* Monthly Notices, xxv, 243, and xxvi, 1 and 204. † Astr. Nach., No. 1884.

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	Elements of August meteors.	Elements of Comet 1862 III.
Long. of perihelion,	343° 38′	344° 41′
Long. of node,	138° 16′	137° 27′
Inclination,	64° 3′	66° 25′
Perihelion distance,	0·9643	0·9626
Motion,	retrograde	retrograde
Perihelion passage,	July 23·62	Aug. 22·9, 1860
Period,		123·4 years

These elements do not differ by quantities greater than can be accounted for by the want of precision in the data for computing the paths of the meteors. We come thus to the unexpected conclusion, *that the great comet of* 1862 *is nothing else than one of the August meteoroids, and probably the largest of them all.*

At the time of announcing this relation of the comet of 1862 with the August meteors, Mr. Schiaparelli found no comet having similar relations with the November meteors. But upon the publication by Oppolzer shortly after,* of the corrected orbit of the comet 1866 I, the resemblance of its elements to those of the orbit of the November group on the supposition of a period of 33·25 years was strikingly manifest, attracting at once the notice of several astronomers.† The following comparative elements are given by Schiaparelli (Bullettino Meteor., Feb. 28, 1867).

	Nov. Meteors.	Comet 1866 I.
Perihelion passage,	Nov. 10·092, 1866.	Jan. 11·160, 1866.
Passage of descending node,	Nov. 13·576	
Long. of Perih.,	56° 25′·9	60° 28′·0
Long. of Asc. Node,	231° 28′·2	231° 26′.1
Inclination,	17° 44′·5	17° 18′·1
Perihelion dist.,	0·9873	0·9765
Eccentricity,	0·9046	0·9054
Semi-major axis,	10·340	10·324
Periodic time,	33·250	33·176
Motion,	retrograde.	retrograde.

The comet of Tempel, he adds, not only describes, therefore, the same orbit as the November group of meteoroids, but is in the same portion of the orbit, and probably nearer the head than the tail of the group.‡ The observations of November 13th, 1865, showed that the earth traversed the anterior portion of the swarm at that time. Two months later the comet passed the node, and ten months afterward the earth, returning to the node, encountered a dense portion of the stream.§

* Astr. Nach., No. 1624.

† Peters, Astr. Nach., No. 1624; Oppolzer, ibid. No. 1626; Schiaparelli, ibid.

‡ The computed elements of the comet of 1866, though very uncertain, resemble those of comet 1866 I, and may belong to the same body. There was a remarkable star-shower in 1866 shortly after the computed perihelion passage of the comet.

§ The total length of the stream would exceed 500,000,000 miles.

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The comet 1862 III (sometimes called 1862 II by not counting Encke's comet), which seems thus to have such interesting relations with the August meteors, was discovered on the evening of the 18th of July, 1862, by Mr. H. P. Tuttle at Cambridge, Mass., and a little later on the same evening by Mr. Thomas Simons at Albany, N. Y.* It was first seen in Europe on the 22d of July, and remained visible more than two months. At its brightest its nucleus was equal to a star of the second or third magnitude, and its tail, according to some observers, was as much as 25° in length. The changes that took place in the coma and tail were quite remarkable, and were carefully observed. They will now possess a double interest.

The telescopic comet 1866 I was discovered by Tempel on the 19th of December, 1865, and was visible about a month. Its minimum distance from the earth's orbit was ·00660, about two and a half times the distance from the earth to the moon. This distance for Tuttle's comet is ·00472, or about 430,000 miles.

4. *Age of the November group of shooting stars.*

In the Paris Academy of Sciences, Jan. 21st, 1867, LeVerrier spoke of the November meteors (Comptes Rendus, lxiv, 94). Inasmuch as the group is not a complete ring, he argues that it is of comparatively recent formation, having come into the solar system, and been turned into its present orbit within a few centuries.

Now a body coming from a great distance and so having a great velocity in the vicinity of the earth could not be thrown into an orbit nearly circular by the feeble action of the lower planets. Computation leads to this result, which is fully confirmed by the fact that the swarm passes every 33 years near the earth and yet returns at *regular* intervals.

Assuming then an orbit whose period is 33¼ years, whose perihelion distance is 0·989, viz., the earth's distance from the sun on the 14th of November, and assuming the position of the radiant to be long. 142°, N. lat. 8½°, he computes corresponding elements.

The group, when it came into the system, could not be thrown into its present orbit except by a powerful perturbing cause, as was the case with the comet of 1770. Moreover, comets so acted upon that the newly acquired orbit has a small perihelion distance, return necessarily to the orbit of disturbing body, just as the comet of 1770 returned to Jupiter. We cannot help then being struck with the circumstance that the November group extends to the orbit of Uranus and a very little farther; and

* Mr. Swift, of Marathon, N. Y., claims to have seen it two or three days earlier, but he made no announcement of the discovery, supposing it to be another comet.

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that these orbits intersect, very nearly, just after the group passes its aphelion, and above the plane of the ecliptic.

The question then arises whether the group and Uranus have ever been together at this point. By calculation it is found that no such meeting could have taken place since the year 126 of our era, and that by a change of the computed node for that epoch by 1° 48′, and by placing the perihelion 4° from the descending node in November, the group would then actually strike the planet Uranus. These two changes are not greater than the possible errors of our observations.

LeVerrier's researches farther show that a globular group one-third of the diameter of Uranus (more or less) might at that time have been then thrown into a shape and an orbit which should by this time give all the phenomena of the November meteors. Its previous orbit might have been an ellipse, a parabola, or a hyperbola.* Its motion might even have been direct in an elliptic or parabolic orbit.

In the course of future time, he argues, the phenomena will extend over a larger and larger number of consecutive years, diminishing, at the same time, in intensity. But no change in perihelion distance will make them disappear entirely. Even if this group again meets Uranus, the planet can act only upon a part of its matter, and cannot throw it all into a new orbit as Jupiter did the comet of Lexell.

These reasonings of Schiaparelli and LeVerrier have certainly great force, and make it probable that of the five possible periodic times of the November meteors (this Journal, xxxviii, 57), that of 33·25 years is the true one. The strongest objection to this conclusion is that the radiant in November does not seem to be a point, but rather a small area. This area cannot be of great breadth in latitude since the ring is only twenty-five or fifty thousands of miles in thickness. If, as observations seem to require, the radiant extends in longitude two or three degrees only, then the lines of apsides of the orbits of the several members of the group differ considerably. In this case it is more reasonable to suppose the orbits themselves grouped about an exact circle than about a long ellipse.

If upon examination it shall be found that the center of the radiant area was decidedly more or less than 89½° from the sun, on the morning of the 14th of November last, then this objection will lose much of its force. Again, if there shall not be seen on the morning of May 12th, 1867, between 1 o'clock and dawn, a few scattering members of the November group, radiating from a point 180° from Leo, this also will tend, to a certain extent, to strengthen Schiaparelli's reasonings.

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ART. XXXII.—*Observations upon the Drift phenomena of Southwestern Iowa;* by C. A. WHITE, M.D.

[In advance of his final report upon the Geology of Iowa.]

IN the year 1858 I discovered distinct glacial scratches upon an exposed layer of the Upper Burlington limestone (Subcarboniferous), and made full notes and drawings of the same, which having been unfortunately destroyed by fire within a year afterward, no account of the observations was ever published. No opportunity has since presented itself to verify those observations, but I think I am not mistaken in the recollection that there was but one set of scratches, which were straight, distinct, and rather numerous; having a direction south, about twenty-two degrees east. This, so far as I am aware, was the first observation of glacial scratches upon rocks *in situ* in the state of Iowa, although boulders with similar scratches upon them are often seen in various parts of the state.

During my official labors last season, although considerable attention was given to the drift deposit, no similar traces of glacial phenomena were ever discovered until I reached the Missouri river in Mills county, where, on section 16, township 71, range 43, west of the fifth principal meridian, very distinct glacial scratches were found upon limestone of the Upper Coal-measures, not far from the middle of the series.

The locality is upon the western abrupt slope of the bluffs which border the bottom land of the Missouri river. The river being distant nearly three miles to the westward, the exact height of the scratches above it was not definitely ascertained, but it is probably not much less than one hundred feet above the ordinary stage of water. About four feet in thickness of ordinary drift material rested upon the striated surface. This had been partially removed by the quarrymen, exposing the scratches to view. Resting upon this light deposit of drift, and sloping upward to the high lands, are about one hundred and fifty feet of that peculiar lacustrine deposit called by Dr. Owen "siliceous marl," and by Prof. Swallow the "Bluff formation," which deeply covers the drift and underlying rocks of this region, except where they have been exposed by fluviatile denudation.

The boulders and pebbles contained in the drift material of this locality were both granitic and metamorphic. They were well rounded and worn, and striated faces were observed upon quite a number of them, thus as nearly as possible detecting them in the very act of scoring the rocks *in situ*.

The scratches here are in two sets, a coarser and a finer; those of the latter more numerous than the former, but those

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of both sets being perfectly parallel with their fellows, distinct and straight. The surface of the rock had been ground level and smooth, removing all unevenness of the natural bedding surface. The directions of the striæ were determined by a very good pocket compass. That of the coarser set (No. 1) was found to be S. 20° E., and that of the finer set (No. 2) S. 51° E. No allowance was made in either case for the variation of the magnetic needle, which the local surveyors calculate at about eleven degrees east of north.

At an exposure of the same limestone one mile below Omaha, the capital of Nebraska, immediately upon the right bank of the Missouri river, and only some six or eight feet above the ordinary stage of water, other scratches of a similar character were observed. They were found upon the upper surface of a firm layer, which the workmen had exposed and were removing for building purposes. Here, however, there is but one set of scratches, their direction being S. 41° W. (set No. 3), not allowing for variation of the magnetic needle. The surface of the rock is nearly or quite level, but the roughness of the natural bedding surface has not been entirely removed, yet the striæ were so distinct that no difficulty was found in ascertaining their true direction.

The drift at this locality is principally composed of a dark colored, stiff, clayey material, intermixed with sand, gravel and boulders, and varies from one foot to eight feet in thickness. Upon this rests the bluff formation as before described. The face of the bluff at the locality where the latter observations were made is nearly at right angles with the direction of the striæ.

Considering that the whole region surrounding these localities, and for a long distance to the northward of them, is an entirely open country; that the present prominently uneven features of the region had their origin at a period subsequent to the drift; and the extreme simplicity and uniformity of the strata over which the glaciers must have moved, the direction of their currents which these scratches apparently indicate seems very remarkable. We not only see at the Mills county locality that the scratches upon one and the same surface prove that two separate currents existed there during some portions of the glacial period, having a divergence of thirty-one degrees with each other, but also, only about twenty miles to the northward, we find the evidence that another current moved in a direction which formed an angle of ninety-three degrees with one of those in Mills county.

Since we see no evidence of the cotemporaneous existence of obstructions which might have deflected the current of a regular southerly moving glacier, and thus have produced the scratches

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in the various directions shown, it seems necessary that we should seek for some other explanation of them. Observations thus far made certainly afford very inadequate data upon which to base a definite theory concerning the real direction of glacial currents over this part of the continent, but the coincidence of the direction of those scratches which have been observed with the general course of the drainage of the region in which they occur, is worthy of careful consideration. By reference to the mention of the locality, near Burlington, at the commencement of this article, and to a map of Iowa, it will be seen that the direction of the scratches observed there, coincides pretty nearly with the general direction of the drainage of the eastern watershed of the state.

That the close of the drift period left the surface of our state unmarked by strong features, and with shallow, longitudinal depressions which gave initial direction to the courses of the streams, and that these subsequently cut out their own valleys by erosion, there seems to be no reason to doubt. It seems not improbable, also, that these initial depressions in the surface, whether primarily caused by flexures of the earth's crust, as Whitney has suggested, or not, may be regarded to some extent as indices of the general direction of ancient glacial currents.

There is another interesting matter in connection with these observations of drift phenomena along the Missouri river, and the existence of the important lacustrine deposit there. The close of the Drift period evidently left a large depression of the general surface in the region, a portion of which is now occupied in part by the counties of Fremont, Mills, Pottawatomie, Harrison and Monona. This depression became a large fresh-water lake, the borders of which have not yet been definitely ascertained, but no satisfactory evidence of its existence eastward of the East Nishnabotany river has been observed in Iowa. The Missouri river evidently emptied into this lake, and flowed from it, until it became filled with the peculiar deposit of fine, siliceous, marly material, known as the Bluff formation, the character of which is very much the same as that of the muddy material which would now be deposited from the waters of the river if it were possible to throw a permanent obstruction across it. As the valley of the river was gradually deepened during the Terrace epoch, its waters found no difficulty in sweeping out the fine homogeneous material which they had before deposited, leaving those high peculiar bluffs upon each side of its broad bottom. Fresh-water and land shells of existing species, principally Gasteropods, are often found in this deposit, from base to top, and its thickness sometimes reaches more than two hundred feet above the drift material upon which it rests.

Seventy or eighty miles to the eastward of the Missouri river,

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in the southern tier of counties, there are evidences that the drift deposit reaches a thickness of more than a hundred and fifty feet. Westward from that region a sensible diminution of its thickness is seen, and, reaching the region of the Bluff formation along the Missouri river, the drift material is found in all cases comparatively thin, being thinnest where the bluff material is thickest.

At the localities where the scratches were observed, the drift material showed evidences of unusual violence of glacial action, being, as before remarked, only a few feet in thickness; and in some places in the same neighborhood it was entirely wanting, the bluff material resting directly upon the Coal-measure limestone.

An explanation of these facts is naturally sought for. The most plausible seems to be, that glacial action extended more deeply beneath the general surface here than elsewhere, and that the direction and character of the currents were such that the greater part of the drift material was swept away to other places, leaving the lake basin to be filled with water at the close of the glacial period. Further investigations, however, are needed to decide such questions as these.

It is understood that the most reliable information we can obtain in relation to the general direction of ancient glacial currents will be the identification of the transported materials with those at the places of their origin. Very few observations of this kind have yet been attempted in Iowa, and it is but fair to state that those few are not now seen to harmonize clearly with the directions of the glacial scratches just described. I refer to the reputed discoveries of galena and native copper in several of the counties upon the eastern watershed of the state. The only *known* localities from which such materials might have been derived lie to the northeastward, in a direction nearly at right angles with the eastern drainage lines. Again, profusely scattered over the region between the Missouri river and the middle of the state, as far northward as the fourth tier of counties and probably much farther, are boulders and fragments of reddish colored quartzite, closely answering the description given by Dr. Hayden of the rock which encloses the pipestone of southwestern Minnesota, and suspected to be of the same origin.* Should this be the case, it is not easy to see how they could have reached their present locations with glacial currents in the direction of the drainage of the western watershed, particularly if they are of the age to which Dr. Hayden has referred the rocks of that famous locality; for in that case they cannot be presumed to have ever existed much farther to the eastward.

* See F. V. Hayden on the Geology of Northeastern Dakota; this Journal, January, 1867.

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The quartzite boulders in the region referred to are promiscuously intermixed with those of other metamorphic and of granitic origin, but those of the red quartzite are everywhere a little less waterworn and more angular than the others, suggesting a less distance of transportation, which would really be the case if derived from the pipestone region.

Iowa City, Iowa, Feb. 14th, 1867.

ART. XXXIII.—*On the General Metallurgical method of Messrs. Whelpley and Storer;* by T. STERRY HUNT, F.R.S.

THE processes having reference to the working of metallic ores, designed and introduced by Dr. James D. Whelpley and Col. Jacob J. Storer of Boston, offer numerous points of interest both mechanical and chemical, which it is proposed to notice briefly in the present paper.

1. The first step in the treatment of ores is their sub-division, which is effected by two novel and ingenious machines, called respectively the breaker and pulverizer. The first of these consists of a horizontal circular table of heavy iron, forty-two inches in diameter, revolving about one thousand times in a minute, having bolted to its upper surface four or more radial bars or blocks of chilled iron, and surrounded by a fixed upright perforated screen. The ore in fragments not more than six inches in diameter, falling into this aperture, is broken by the revolving bars into dust and small grains which are ejected through the perforated screen or curb, from which the larger particles are thrown back to complete the breaking. Such a machine with fifteen horse-power will break to the size of sand and coarse gravel eighteen or twenty tons of quartz or hard ore per hour.

The pulverizer is properly designated as an air-mill, and consists of a horizontal shaft, furnished with arms or paddles, which are made to revolve from one to three thousand times a minute, within an inch of the inner surface of a steel-lined cylinder varying from eighteen to forty inches in diameter. The previously crushed ore is introduced through an opening in the center of a plate, which covers one end of the cylinder, and is perforated with numerous small holes. The other end is connected through a diaphragm having an axial opening, with an ordinary fan-blower generally attached to the same shaft that carries the paddles. The mutual attrition of the particles of ore at the rapid rate of revolution communicated to them in the peripheral space of the mill, reduces them to fine dust, which as soon as formed is removed from the cylinder by the current of air drawn

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by the fan through the perforated end, and blown into large chambers, where it is deposited. While the interaction of their particles in the mill rapidly pulverizes brittle bodies, malleable metals, in the same conditions, are soon beaten into rounded pellets. It is proposed to apply this principle to the treatment of the native copper of Lake Superior, which may then be readily separated from its earthy gangue reduced to dust by the pulverizer. This air-mill has been employed for the pulverization of various drugs, of coal, for use as a combustible in the manner about to be described, and even for the grinding of cereals, for all of which purposes it may be adapted. It has also been employed, on a large scale, to pulverize bones for use as a fertilizer. One of these air-mills forty-two inches in diameter, and moved by fifteen horse-power will reduce from 2,000 to 3,000 pounds per hour of quartz, or hard ores, to a powder many times finer than can be obtained by the use of stamps.

2. The calcination of the pulverized ores is effected in what Messrs. Whelpley and Storer call the Water-furnace. This consists of a fire-tower, from twenty to thirty feet high, built of brick, with double walls, and somewhat conical in form, being from three to four feet in diameter at the top, and from four to six at the bottom. Around its upper part are built four fire-boxes, opening into the tower near its summit, which is closed and connected with a large fan-blower. By means of this, besides an abundant supply of air, more or less heated by passing between the two walls of the tower, ore and fuel, in the state of dust, are carried downward into the furnace. The effects obtained by the combustion of charcoal or other fuel pulverized and borne in a current of hot air, are very surprising. The finely divided combustible, being kindled by the flame drawn from the fire-boxes, burns in the descending current with great energy, and from the comparatively large surface exposed to the action of the air, generates a great amount of heat, and, with an excess of fuel, an intense light. The great fiery blast, nearly filling the tower, can at pleasure be made oxydizing or reducing in its action, by regulating the supplies of fuel and of air. I have seen it, at twelve feet from the top, so potent as to heat rapidly to whiteness two feet of a wrought iron bar an inch in diameter, and cause it, though supported at both ends, to bend like wax beneath its own weight in thirty seconds after it was placed in the blast. The powerful heating effects which may be obtained by this use of pulverized fuel are readily understood when we consider that a cubic inch of coal, reduced to particles one five-hundredth of an inch in diameter, will present to the action of the atmospheric oxygen a surface equal to not less than twenty-one square feet. This application of fuel promises to have important results for heating reverberatory, muffle

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and glass furnaces, for the working of iron, and even for the generation of steam. Solid combustibles are by this method practically volatilized, and broken and refuse fuel is made available.

The calcination of sulphuretted ores, however, requires but a comparatively low temperature, and an abundant supply of oxygen. The fire-tower of the water-furnace, being heated to redness, the ore, with or without addition of pulverized fuel, is driven by a small fan into the great current of air down the tower; the sulphur and the base metals are rapidly oxydized and the calcined material falls into the water-tank beneath, while the current of air passes through successive chambers, built over this tank, and open to it beneath. This movement is aided by a large fan-wheel placed at the end of the series, which being furnished with paddles dipping into the water, produces in the final chamber a great amount of spray, serving alike to precipitate the suspended dust, and promote the absorption of the sulphurous acid gas. The escape of the excess of this into the air, provided it is not required for farther use, is prevented by a second spray-wheel beyond, supplied with milk of lime or some other absorbent.

In the case of sulphuretted ores of copper, the water tank is filled with a solution of the chlorids of sodium and calcium, by which, with the aid of the spray-wheel, the sulphurous acid is absorbed, and the oxyd of copper converted into dichlorid. This beautiful process, devised by Messrs. Whelpley and Storer, I have submitted to examination, and have found that the reaction taking place may be represented as involving one equivalent of chlorid of calcium, one of sulphurous acid, and two of cupric oxyd, and giving rise to one equivalent of sulphate of lime, and one of dichlorid of copper,

$$CaCl+SO_2+Cu_2O_2=SCaO_4+Cu_2Cl.$$

A solution of chlorid of calcium holding oxyd of copper in suspension, rapidly absorbs sulphurous acid gas, and if sufficiently concentrated, is converted into a white crystalline magma of gypsum and dichlorid of copper. This latter salt I find to be soluble in a boiling hot solution of chlorid of calcium, which, however, again deposits it on cooling, a reaction which may probably be found available on a large scale in separating copper from some other metals. In ordinary cases, however, the precipitation of the dichlorid of copper in the furnace-tank is prevented by the presence in the bath of chlorid of sodium, in which, as is well known, the cuprous chlorid is readily soluble.

The calcined and oxydized ore falling into the tank which extends sixty feet or more beneath the furnace and its chambers, is carried forward, with constant agitation, by means of a sub-

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merged rotating helix, and at length falls into a well at the extremity, from which it is withdrawn, freed from oxyd of copper, but generally containing a small residuum of unoxydized sulphid, which, if of sufficient importance, is separated by a repetition of the process with the Water-furnace, or by a rapid calcination in a reverberatory, of the mass impregnated with chlorids, by which means the residual copper left by imperfect burning becomes readily soluble in the sulphurous chlorid bath of the water-tank.

A small but variable proportion of protochlorid of iron generally accompanies the chlorid of copper, and may be separated from the cuprous solution by a simple reaction which I also studied. Three equivalents of cupric oxyd, and two of ferrous chlorid, yield by their reaction one equivalent each of cuprous and cupric chlorids, and one of sesquioxyd of iron,

$$Cu_3O_3+Fe_2Cl_2=Cu_2Cl+CuCl+Fe_2O_3.$$

The addition to the heated solution, separated from gypsum and insoluble matters, of a portion of cupric oxyd therefore suffices to precipitate the whole of the dissolved iron, and the dinoxyd of copper in the presence of air rapidly produces a similar result. The addition of milk of lime now throws down, from the solution of cuprous chlorid, the whole of the copper as pure hydrous dinoxyd, whose subsequent reduction to the metallic state is a very simple operation. Meanwhile the chlorid of calcium is regenerated, and the bath restored to its original condition may thus be used an indefinite number of times, the only reagent consumed in the process, in addition to the elements of the ore, and the oxygen of the air, being the equivalent of lime used to precipitate cuprous oxyd.

It will be seen that for sulphuretted ores containing gold, the treatment in the fire-tower, with the aid of a bath of water only, affords a simple mode of desulphurization, and leaves the gold particles in a state most favorable for amalgamation, while in the case of auriferous ores containing copper, a similar result may be obtained, and the copper, which is lost in the ordinary method of working such ores, recovered by means of the chlorid bath.

It is claimed by the designers of this series of processes, that copper can in this way be produced, at about one-third the cost of the ordinary method. The small consumption of fuel, and the mechanical facilities afforded for handling great masses of material, are such, that the new method will probably be found especially advantageous, in the treatment of low grade ores, in regions where transportation is difficult, and fuel scarce. The patentees have a small experimental furnace eighteen feet high, at East Boston, but are now erecting at the Harvey Hill mine,

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near Quebec, a furnace thirty feet high, which, it is expected, will enable them to treat fifty tons of seven per cent ore in twenty-four hours.

The application of the Water-furnace to the treatment of the sulphuretted ores of other metals, presents many points of interest, whose consideration is reserved for another time.

Montreal, Feb. 21, 1867.

ART. XXXIV.—*The Repsold Portable Vertical Circle;* by CLEVELAND ABBE.

(Continued from page 216.)

As to the methods and formulæ used in connection with the vertical circle, it is evident that we need first some means of orientation on arriving at a new station. An observation of any terrestrial object will give an approximate knowledge of the zenith point, and an approximate value of the latitude is easily had from a map or by estimation. With one pointing upon any recognizable celestial object, we have then its azimuth and zenith distance for a given observed moment, whence the following computation gives us the approximate north point of the azimuth circle and the hour angle.

$$\text{Put}\quad \begin{array}{lll} 90^\circ-\delta=a & s-a=\alpha & x=\sqrt{\dfrac{\sin\alpha\sin\beta\sin\gamma}{\sin s}} \\ 90^\circ-\varphi=b & s-b=\beta & \\ z=c & s-c=\gamma & \Sigma=\dfrac{x}{\sin s} \\ \hline 2s=a+b+c & 2s=\alpha+\beta+\gamma & \end{array}$$

The Gaussian formulæ give for the azimuth, parallactic angle and hour angle,

$$\text{(B.)}\quad \tan\tfrac{1}{2}A=\frac{x}{\sin\alpha}\qquad \tan\tfrac{1}{2}p=\frac{x}{\sin\beta}\qquad \tan\tfrac{1}{2}t=\frac{x}{\sin\gamma}$$

$$\tan\tfrac{1}{2}A\,\tan\tfrac{1}{2}p\,\tan\tfrac{1}{2}t=\Sigma.$$

The computation with its controls is of course performed with 4-figure logarithms. The observed azimuth, plus or minus the computed A, gives the north point of the circle. The computed t, plus the tabular R.A., gives the sidereal time, whence is found the clock correction.

A previously computed ephemeris of the stars to be observed enables us now to point upon any one. Polaris will naturally be first chosen, as by it we may more accurately determine the north point or adjust the azimuth circle to N.P.=0°, as is most convenient if any number of observations is to be made.

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An ephemeris of the azimuths and zenith distances of the principal stars, if computed for every 5° of latitude, will serve by interpolation for any intermediate position. The formulæ for the computation of finding ephemerides as given by Mr. Döllen are very simple.

Put $z-(\varphi-\delta)=r$; the well known formula,

$$\cos z=\cos(\varphi-\delta)-2\cos\varphi\cos\delta\sin^2\tfrac{1}{2}t,$$

gives

$$\text{(C.)}\qquad \sin\tfrac{1}{2}r=\cos\varphi\sin^2\tfrac{1}{2}t\frac{\cos\delta}{\sin(\varphi-\delta+\frac{1}{2}r)}.$$

Another well known formula may be written

$$\text{(D.)}\qquad \sin A=\sin t\frac{\cos\delta}{\sin(\varphi-\delta+r)}.$$

Or by a transformation of

$$\sin z\cos A=-\cos\varphi\sin\delta+\sin\varphi\cos\delta\cos t,$$

these results, approximately,

$$\text{(D'.)}\qquad \sin^2\tfrac{1}{2}A=\sin\varphi\sin^2\tfrac{1}{2}t\frac{\cos\delta}{\sin(\varphi-\delta)}.$$

Neglecting the r in the second members of these equations, they admit of a very simple arrangement for the computation of an ephemeris whose argument is the time for stars near the meridian, being sufficiently accurate within the limits

$$\varphi-\delta>10^\circ \text{ and } t<15^\circ.$$

For an ephemeris in the neighborhood of the prime vertical we may use the azimuth as argument; counting it from the west point northward, we have

$$\text{(E.)}\qquad \sin\delta=\sin\varphi\cos z+\cos\varphi\sin z\sin A$$

$$\text{(F.)}\qquad \tan\delta=\frac{1}{\cos\varphi}\sin t\tan A+\tan\varphi\cos t.$$

Put $\tan\zeta=\dfrac{\sin A}{\tan\varphi}$ and $p=\dfrac{\cos\zeta}{\sin\varphi}$;

the first formula (E) becomes

$$\text{(G.)}\qquad \cos z'=\cos(z-\zeta)=p\sin\delta;$$

whence $z=z'\pm\zeta$.

Put $\tan\omega=\dfrac{\tan A}{\sin\varphi}$ and $q=\dfrac{\cos\omega}{\tan\varphi}$;

the second formula (F) becomes

$$\text{(H.)}\qquad \cos t'=\cos(t-\omega)=q\tan\delta;$$

whence $t=t'\pm\omega$.

The arrangement of these computations can be made exceedingly convenient. Extensive ephemerides for latitude 35° to 70° north have been published by General Tenner; provided with

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these or similar special ones the observer loses no time in selecting the pair of stars to be observed. The latitude stars are of course observed on the meridian as nearly as possible, excepting the polars, which are observed at any hour angle.

In the accurate computation of the results, the following formulæ are used by Mr. Döllen, following Struve's habit of separately reducing each observation.

a. For the polars, all observed zenith distances are reduced to the upper culmination. The formula (C) may be written

$$\text{(L)} \qquad \sin\tfrac{1}{2}(z-\zeta)=\cos\varphi\cos\delta\,\frac{\sin^2\tfrac{1}{2}t}{\sin\tfrac{1}{2}(z+\zeta)},$$

or approximately

$$\text{(J.)} \qquad r=z-\zeta=\frac{2\cos\varphi\cos\delta}{\sin 1''}\cdot\frac{1}{\sin\tfrac{1}{2}(z+\zeta)}\cdot\sin^2\tfrac{1}{2}t,$$

where

$$\zeta=\varphi-\delta.$$

Provided with the Wrangell or other convenient extended tables of $\sin^2\frac{1}{2}t$, and assuming an approximate φ and zenith point and using the value of $z+\zeta$ for the middle of the series as a constant throughout the whole, we easily compute the individual values of r whence result the circle readings for each observation as if it had been made at the upper culmination. The mean of the four observations circle right and the four circle left gives the correct zenith point, the zenith distance ζ and the approximate latitude. With these a second approximation is made, and more will not generally be required. In the second approximation the new refractions and $\sin\frac{1}{2}(z+\zeta)=\sin(\varphi-\delta+\frac{1}{2}r)$ need not be anew computed, since the first differences of the logarithmic tables will give the $\Delta\log r$ corresponding to the $\Delta\varphi$ and Δz.

If the zenith point and latitude are sufficiently well known, it will be equally expeditious to compute the direct formula

$$\cos\zeta=\cos z+2\cos\varphi\cos\delta\sin^2\tfrac{1}{2}t,$$

using of course convenient tables for $\sin^2\frac{1}{2}t$ and Zech's tables for addition.

b. For other stars than the polars observed near the meridian, the direct computation of $\log r$ by means of the following series will be found convenient. We have from (C)

$$\text{(K.)} \qquad \sin r+2\sin^2\tfrac{1}{2}r\cot\zeta=2\frac{\cos\varphi\cos\delta}{\sin\zeta}\sin^2\tfrac{1}{2}t;$$

whence

$$\text{(L.)} \qquad r+\frac{r^2}{2}\cot\zeta\sin 1''-\frac{1}{6}r^3\sin^2 1'',\ \&c.=2\frac{\cos\varphi\cos\delta}{\sin\zeta\sin 1''}\sin^2\frac{t}{2}.$$

Regarding the second member as a first approximation to r, and developing the $\sin^2\frac{1}{2}t$, we obtain the following, which is due to Mr. Döllen,

$$\text{(M.)} \qquad \log r=\log(pt^2)-qt^2;$$

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in which we have put

$$g = \text{hourly gain on sidereal time}, \qquad f = \frac{3600^s}{3600+g},$$

$$\beta = 3\frac{\cos\varphi\cos\delta}{\sin\zeta}, \qquad \gamma = \cot\zeta,$$

$$p = \frac{37{\cdot}5}{R} f^2\beta = [6{\cdot}25961] f^2\beta,$$

$$q = \frac{\text{Mod}}{2R} p\left(\frac{1}{\beta} \pm \gamma\right) = [9{\cdot}0223]\, p\left(\frac{1}{\beta} \pm \gamma\right).$$

c. For the computation of the hour angle from the observed zenith distances in the prime vertical, we have the simple formula

$$\text{(N.)} \qquad \sin^2\tfrac{1}{2}t = \frac{\cos\zeta}{2\cos\varphi\cos\delta}\left(1 - \frac{1}{\underset{\cos z}{\underline{\cos\zeta}}}\right);$$

the computation of which is sufficiently expeditious even with six-figure logarithms, if we are provided with the tables previously mentioned. The second approximation, using a correct zenith point, is made if necessary as before, by using the tabular first differences.

As the formula (A) shows the flexure of the tube to be not symmetrical with respect to the zenith, it is necessary for greater accuracy to correct the results given by each star of a pair, according to the formula

$$f = b\sin(z + B).$$

The correction, f, is directly applicable to the zenith distances observed for latitude.

For the time determination we have the differential formula

$$\text{(P.)} \qquad dt^s = \frac{\sin z}{15\cos\varphi\cos\delta\sin t}\, dz''.$$

The application of these corrections is, especially for the latitude, necessary in order to entirely free the result from a pair of opposite stars from the influence of flexure.

To the preceding sketch of the instrument and its formulæ may be added a few words as to the conduct of the field work, which may be carried on without inconvenience at a temperature of 15° or 20° Fahrenheit.

In the Russian empire, where railroads do not offer sufficient accommodation to the geodesist, it is necessary that an expedition should be provided with an easy spring-van drawn by two or three horses (the Russian officer is only perfectly happy when rushing along with his *troika*). In this covered wagon the twelve or fifteen chronometers are as well as possible protected against rapid changes of temperature and disturbing jars. One or two barometers with thermometers are provided; the barometers of Brauer's construction have been found to endure surpris-

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ingly well the rough usage to which they must needs be subjected in journeys of thousands of miles. A heavy tripod is provided, and the means for leaving a suitable simple mark at any station. The vertical circle, without being in the least taken to pieces, is received as a whole into its small neat case in which two clamps firmly fasten it, an outer thick leather cover with handles protects the whole, which is carried with ease by two men, or by one if need be, as it scarcely weighs sixty pounds. The entire load occupies a space of some twenty cubic feet.

Arrived at the previously reconnoitred station, five or ten minutes suffice for the two attendants to erect the tripod and set the vertical circle upon it; sometimes a block of stone or three stakes of wood support the feet of the tripod and remain to mark the station. Meantime the horses having been unhitched and the barometer and thermometers hung up, the chronometers (including the extremely under- or over-compensated ones) are, by means of the one beating 13 times in 6 seconds, very rapidly compared with the one to be used in the observations. The examination of the state of the instrument and the adjustment of the verticality of the vertical axis follow, and in a few minutes after observing the Sun or Moon, Polaris is in the field of view. Although one determination only of time is necessary, it is better to make two, arranging the work as follows:

1. Comparison of chronometer.
2. Reading of barometer and thermometer.
3. Observation of pair of stars for time.
4. Reading of barometer and thermometer.
5. Observation of pair of stars for latitude.
6. Reading of barometer and thermometer.
7. Observation of pair of stars for time.
8. Reading of barometer and thermometer.
9. Comparison of chronometer.

The observations are now complete and the party may proceed to the next station; if any considerable time elapses the departure should be immediately preceded by another comparison of chronometers.

The time spent at any station must depend upon the skill, energy and self-devotion of the observer. In the expedition by Döllen and Hübner in 1855–56 in the province of Perm, cases occur where three stations, distant twenty-five to forty miles from each other, have been thus occupied within the space of thirty-six hours, the time spent at each being about three hours, the intervening distances being travelled over very ordinary roads. It is often very advisable to work expeditiously in order to improve a few days of consecutive clear weather and secure a quick return to the starting point, without having exposed the chronometers to a long absence or dangerous temperature changes. This latter point is one requiring especial and intelli-

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gent watchfulness on the part of the observer. Captain Bolscheff, having charge of the determination of some two hundred points in Finnland, mentioned to me the difficulties that he had to contend with arising from the sudden fall in the atmospheric temperature during the night, obliging him sometimes to stop while proceeding from one station to another, not only to make extra comparisons of his chronometers, but by artificial warmth to endeavor to counteract the influence of the rapid fall in the exterior temperature.

Without here farther entering into the details of the methods pursued by Colonel Smyssloff in obtaining the final corrections for the rates of his chronometers and the longitudes of his stations relative to Poulkova, we will note that the twenty stations here given cover an area of some 135 miles square in the provinces of Novgorod and St. Petersburg, and the expeditions occupied him from the 18th of June to the 31st of July, 1859. Two journeys were undertaken, the first leaving Poulkova June 18th, visited stations I, 2, II, 2, III, 3, 4, 5, 6, I, returning to Poulkova July 3d. The second left Poulkova July 5th, and visited IV, VI, 7, 8, 9, IV, arriving at Nova Ladoga the 13th of July; the same day leaving Nova Lagoda, and visiting 10, IV, 9, 13, V, 14, 15, I, it returned to Poulkova July 31st. The whole distance travelled in this six weeks expedition was 1400 miles, of which 175 were by railroad. Each latitude depends upon eight pointings upon Polaris and eight upon some southern star; the probable error of each resulted in general $\pm 0''\cdot 3$. Each longitude (as to the fourteen secondary stations) depends in general upon one time determination; the probable error of each is given below. Ten chronometers were carried, besides the non-compensated one and the one beating $\frac{6}{13}$ seconds and the one used in observing. There were in all twenty-nine determinations of time and fifteen of latitude.

Station.	Latitude. Probable error $\pm 0''\cdot 3$.	Longitude from Poulkova.	Prob. error. ±
	° ′ ″	m. s.	s.
1. Spasska Orlayno,	59 15 53·8	− 0 53·43	0·08
2. Kamenni Polarne,	58 48 39·8	+ 1 28·34	0·07
3. Arm Spasska Poleust,	58 55 15·7	+ 4 44·91	0·09
4. Korovay Roustchay,	59 13 24·8	+ 3 25·33	0·08
5. Samost,	59 29 31·8	+ 3 46·20	0·09
6. Uspensko,	59 41 45·9	+ 3 9·00	0·10
7. Rougoi,	59 28 13·8	+10 7·61	0·12
8. Oskoua,	59 16 43·5	+ 7 2·95	0·12
9. Podzopie,	59 38 43·6	+ 7 10·61	0·10
10. Schassenske,	60 3 28·2	+12 34·52	0·10
11. Taykvayn,	59 38 48·5	+12 44·35	0·08
12. Podsosno,	59 14 32·2	+12 52·73	0·10
13. Krayvar Gora,	59 3 8·1	+11 7·87	0·09
14. Morkonnayzi,	58 50 24·0	+10 29·38	0·09
15. Malar Veschera,	58 50 51·0	+ 7 33·91	0·08
16. Nova Ladoga,	60 6 40·3	+ 7 58·78	0·05

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As fundamental points of reference for the longitudes the following list was selected of points determined in previous years.

Station.	Latitude.	Longitude.
		0^h 0^m 0^s
I. Poulkova,	59° 46′	
II. Louga,	58 43	−0 1 54·20
III. Novgored,	58 30	+0 3 47·86
IV. Nova Ladoga,	60 7	+0 7 58·80
V. Borovaytsche,	58 24	+0 14 19·93
VI. Taykvayn,	59 39	+0 12 44

Of these, however, it was preferred to include IV and VI among those to be independently determined on the present occasion, and they have received the numbers 16 and 11 in the previous list.

Among several similar expeditions that have come to my notice, I may mention those before referred to, of Messrs. Döllen and Hübner in 1855–56 in the government of Perm, where many points have been unusually carefully determined with reference to Perm and Ekaterineberg; and that of Captain Bolscheff in Finnland in 1863–66, each of whose 150 points has been twice independently determined.

An extensive series of observations made at Poulkova with a vertical circle, made in 1857 by Messrs. Repsold, still farther attests, if any farther proof were wanted of the reliability of the results afforded by this instrument—to observe with which is in fact a luxury of convenience. The observations made on distant terrestrial signals—the reflection from gilded church domes—gave for perfect condition of images the probable accidental error of a zenith distance resulting from two pointings in opposite positions of the circle $\pm 0''\cdot 52$, a large portion of which may fall upon the level, which was afterwards improved by the addition of a narrow mirror reflecting the divisions horizontally to the observer's eye.

A suggestion of Mr. Döllen as to the interest that would attach to a comparison of the results obtained by the vertical circle with those obtained by using the Talcott zenith telescope —and the suggestion that by clamping the vertical circle and observing stars of exactly equal zenith distances, thus freeing the results from errors arising from imperfect graduation of the circle, by converting the vertical circle into a very convenient zenith telescope—both seem to be well worthy of being put into execution. In the determination of time I have been able to apply this latter method of using the vertical circle: it remains to attempt the same in the determination of latitude.

37 East 20th st., New York, January, 1867.

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Art. XXXV.—*On the Reduction of Meteorological Observations;* by Erastus L. DeForest.

The system of twelve equations for correcting monthly means for the unequal length of the months, given by me in this Journal, vol. xlii, page 155, was obtained on the supposition that the year consists of 365¼ days. The true length of the year being a very little less than this, it follows that the equations referred to are not exactly correct. The amount of inaccuracy in their results is indeed very small, but still it seems desirable that fundamental formulas of this kind should not involve any unnecessary errors, however small they may be. The equations can be computed just as well by giving the year its true length, care being taken to assign the true values to the arcs n_1, n_2, n_3, and c, which measure the lengths of the months, and also to the small arc x_1, which measures the time from the middle of a calendar month to the middle of the corresponding mean month.

On the assumption that the year contains 365·24224 days, a mean month will contain 30·43685 days, and the calendar month of February 28·24224 days. A month of 31 days will be represented by the arc 30° 33′ 18″·2, a month of 30 days by 29° 34′ 9″·9, and the month of February by 27° 50′ 12″·8. The values of x_1 for the several months are therefore

January,	−0°	16′	39″·1	July,	1°	4′	53″·6
February,	+0	31	35 ·4	August,	0	31	35 ·4
March,	1	19	49 ·9	September,	0	27	51 ·3
April,	1	16	5 ·8	October,	0	24	7 ·3
May,	1	12	21 ·7	November,	0	20	23 ·2
June,	1	8	37 ·7	December,	0	16	39 ·1

and the twelve equations are found to be

$$
\begin{aligned}
M_1 &= m_1 + \cdot0037\, m_1 + \cdot0030\, m_{12} - \cdot0067\, m_2 \\
M_2 &= m_2 - \cdot0127\, m_2 - \cdot0031\, m_1 + \cdot0158\, m_3 \\
M_3 &= m_3 + \cdot0028\, m_3 - \cdot0249\, m_2 + \cdot0221\, m_4 \\
M_4 &= m_4 - \cdot0042\, m_4 - \cdot0200\, m_3 + \cdot0242\, m_5 \\
M_5 &= m_5 + \cdot0016\, m_5 - \cdot0218\, m_4 + \cdot0202\, m_6 \\
M_6 &= m_6 - \cdot0039\, m_6 - \cdot0180\, m_5 + \cdot0219\, m_7 \\
M_7 &= m_7 + \cdot0026\, m_7 - \cdot0200\, m_6 + \cdot0174\, m_8 \\
M_8 &= m_8 + \cdot0025\, m_8 - \cdot0103\, m_7 + \cdot0078\, m_9 \\
M_9 &= m_9 - \cdot0027\, m_9 - \cdot0067\, m_8 + \cdot0094\, m_{10} \\
M_{10} &= m_{10} + \cdot0030\, m_{10} - \cdot0085\, m_9 + \cdot0055\, m_{11} \\
M_{11} &= m_{11} - \cdot0026\, m_{11} - \cdot0046\, m_{10} + \cdot0072\, m_{12} \\
M_{12} &= m_{12} + \cdot0032\, m_{12} - \cdot0064\, m_{11} + \cdot0032\, m_1
\end{aligned}
$$

It will be seen that the numerical coëfficients here given differ from the previous ones to the amount, in some cases, of a single unit in the fourth decimal place. They are, I believe, as nearly exact as they can be made without extending them beyond the

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fourth place, a degree of refinement which would be practically useless. The computation, however, was carefully made to six places, so as to secure the nearest value for the last figure. In rejecting the fifth and sixth places, care has been taken not to impair the condition that in any single equation the sum of the three decimal coëfficients must be zero. The first and seventh equations, as computed to six places, are

$$M_1 = m_1 + \cdot 003668\ m_1 + \cdot 003060\ m_{12} - \cdot 006728\ m_2$$
$$M_7 = m_7 + \cdot 002541\ m_7 - \cdot 019981\ m_6 + \cdot 017440\ m_8.$$

When these are reduced to four places in the usual way, they become

$$M_1 = m_1 + \cdot 0037\ m_1 + \cdot 0031\ m_{12} - \cdot 0067\ m_2$$
$$M_7 = m_7 + \cdot 0025\ m_7 - \cdot 0200\ m_6 + \cdot 0174\ m_8.$$

The sums of the three decimal coëfficients differ from zero to the amount of a single unit in the fourth place; and to correct this, the unit has been added to or subtracted from that coëfficient which is least altered by it, as compared with its true value to six places.

Since the length of a calendar year is either 365 or 366 days, the assumption that the year consists of 365·24224 days is not strictly applicable to meteorological observations for any single year. But the average length of a considerable number of consecutive calendar years approaches very closely to that of the true or astronomical year, and the greater the number of years the closer will be the approximation. Therefore when we are considering the mean results of observations which have extended over a long course of years, the assumption that calendar years and astronomical years are equal will lead to no error. In the same way we are justified in assigning 28·24224 days to February, because this is the average length of that month for a series of many consecutive years.

When the equation of the curve representing the annual course of any meteorological phenomenon, as the mean daily temperature for instance, has been found for a given place by the method of mean months, and it is required to interpolate from it the mean temperature of a particular day, care should be taken to assign the proper value to the abscissa. Take for example the 15th day of March. The time elapsed from the beginning of the year to the middle of that day is $31 + 28 \cdot 2422 + 14\frac{1}{2} = 73 \cdot 7422$ days, and the corresponding arc is found by the proportion

$$365 \cdot 2422 \text{ days} : 73 \cdot 7422 \text{ days} = 360^\circ : 72^\circ\ 41'.$$

The value 72° 41′ being given to the abscissa in the equation of the curve, the resulting value of the ordinate will be the mean daily temperature at the given place on the 15th of March. The abscissa must be reckoned up to the middle of the day, be-

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cause the small arc of the curve which belongs to any one day may be regarded as approximately a straight line, so that the mean of all its ordinates is equal to its middle ordinate, which therefore represents the mean temperature of the day. The subjoined table will be found to facilitate computations. It gives the abscissa for the middle point of each day in the year, correct to the nearest minute, one minute of arc here corresponding to about twenty-four minutes of time.

Arcs representing the mean interval of time from the beginning of the year to the middle of each day.

	Jan.	Feb.	M'ch.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	0 30	31 3	58 53	89 26	119 1	149 34	179 8	209 41	240 15	269 49	300 22	329 56
2	1 29	32 2	59 52	90 26	120 0	150 33	180 7	210 40	241 14	270 48	301 21	330 55
3	2 28	33 1	60 51	91 25	120 59	151 32	181 6	211 40	242 13	271 47	302 20	331 55
4	3 27	34 0	61 51	92 24	121 58	152 31	182 5	212 39	243 12	272 46	303 20	332 54
5	4 26	34 59	62 50	93 23	122 57	153 30	183 5	213 38	244 11	273 45	304 19	333 53
6	5 25	35 59	63 49	94 22	123 56	154 30	184 4	214 37	245 10	274 44	305 18	334 52
7	6 24	36 58	64 48	95 21	124 55	155 29	185 3	215 36	246 9	275 44	306 17	335 51
8	7 24	37 57	65 47	96 20	125 55	156 28	186 2	216 35	247 9	276 43	307 16	336 50
9	8 23	38 56	66 46	97 19	126 54	157 27	187 1	217 34	248 8	277 42	308 15	337 49
10	9 22	39 55	67 45	98 19	127 53	158 26	188 0	218 34	249 7	278 41	309 14	338 49
11	10 21	40 54	68 44	99 18	128 52	159 25	188 59	219 33	250 6	279 40	310 13	339 48
12	11 20	41 53	69 44	100 17	129 51	160 24	189 59	220 32	251 5	280 39	311 13	340 47
13	12 19	42 53	70 43	101 16	130 50	161 24	190 58	221 31	252 4	281 38	312 12	341 46
14	13 18	43 52	71 42	102 15	131 49	162 23	191 57	222 30	253 3	282 38	313 11	342 45
15	14 18	44 51	72 41	103 14	132 48	163 22	192 56	223 29	254 3	283 37	314 10	343 44
16	15 17	45 50	73 40	104 13	133 48	164 21	193 55	224 28	255 2	284 36	315 9	344 43
17	16 16	46 49	74 39	105 13	134 47	165 20	194 54	225 28	256 1	285 35	316 8	345 42
18	17 15	47 48	75 38	106 12	135 46	166 19	195 53	226 27	257 0	286 34	317 7	346 42
19	18 14	48 47	76 38	107 11	136 45	167 18	196 53	227 26	257 59	287 33	318 7	347 41
20	19 13	49 47	77 37	108 10	137 44	168 17	197 52	228 25	258 58	288 33	319 6	348 40
21	20 12	50 46	78 36	109 9	138 43	169 17	198 51	229 24	259 57	289 32	320 5	349 39
22	21 11	51 45	79 35	110 8	139 42	170 16	199 50	230 23	260 57	290 31	321 4	350 38
23	22 11	52 44	80 34	111 7	140 42	171 15	200 49	231 22	261 56	291 30	322 3	351 37
24	23 10	53 43	81 33	112 7	141 41	172 14	201 48	232 22	262 55	292 29	323 2	352 36
25	24 9	54 42	82 32	113 6	142 40	173 13	202 47	233 21	263 54	293 28	324 1	353 36
26	25 8	55 41	83 32	114 5	143 39	174 12	203 46	234 20	264 53	294 27	325 1	354 35
27	26 7	56 40	84 31	115 4	144 38	175 11	204 46	235 19	265 52	295 26	326 0	355 34
28	27 6	57 40	85 30	116 3	145 37	176 11	205 45	236 18	266 51	296 26	326 59	356 33
29	28 5	58 16	86 29	117 2	146 36	177 10	206 44	237 17	267 51	297 25	327 58	357 32
30	29 5		87 28	118 1	147 36	178 9	207 43	238 16	268 50	298 24	328 57	358 31
31	30 4		88 27		148 35		208 42	239 15		299 23		359 30

When the mean daily temperatures at a given place have been tabulated for every day in the year, it seems to have been the usual practice hitherto to omit giving the temperature for the 29th of February. It cannot be said that the meteorological phenomena which occur on a single intercalary day are less important, or less worthy of being observed and recorded and combined with others to form the monthly mean, than are those of any other single day. The interval of time between the mean position of the beginning of the calendar year and the mean position of the middle of the intercalary day is assignable with great precision, and when an equation of temperatures has

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been found by the use of mean months, the mean temperature of the 29th day of February can be interpolated with as much accuracy as that of any other day whatever. The time elapsed from the beginning of the year to the middle of the intercalary day is $31+28+\frac{1}{2}$ of $0{\cdot}2422=59{\cdot}1211$ days, and the corresponding abscissa is found to be 58° 16′.

The monthly means of temperature at New Haven, as given in the Transactions of the Connecticut Academy of Arts and Sciences, from 86 years' observations, are

26·53	46·84	71·66	51·10
28·11	57·28	70·32	40·32
36·09	66·96	62·50	30·42

When reduced to mean months they become

26·5311	47·3076	71·7307	50·9438
28·2410	57·7031	70·2452	40·1992
36·5263	67·2372	62·3404	30·3442

From these data I have obtained the equation of mean daily temperatures throughout the year, in the way already stated in this Journal, xli, 373, except that instead of finally reducing it from the usual form,

$$y=a+a_1\sin(x+E_1)+a_2\sin(2x+E_2)+a_3\sin(3x+E_3)+\text{ \&c.},$$

into a form where the signs before the terms are sometimes plus and sometimes minus, I have reduced it to

$$y=a+a_1\sin(x-e_1)+a_2\sin2(x-e_2)+a_3\sin3(x-e_3)+\text{ \&c.},$$

in accordance with the formula

$$\sin(nx+E_n)=\sin n\left\{x-\frac{1}{n}(360^\circ-E_n)\right\}.$$

This prevents confusion of signs, and at the same time preserves the significance of the arc e_n, making it measure the time elapsed from the beginning of the year to the *first ascending node* of the term in which it occurs.

The New Haven equation of temperatures then is

$$\begin{aligned}y=49{\cdot}112&+22{\cdot}902\sin(x-110^\circ\ 39'\ 22'')+{\cdot}289\sin2(x-20^\circ\ 56')\\&+{\cdot}443\sin3(x-57^\circ\ 42')+{\cdot}022\sin4(x-75^\circ\ 22')\\&+{\cdot}402\sin5(x-3^\circ\ 53')+{\cdot}093\sin6x.\end{aligned}$$

An equation of this kind, to be perfect, ought to express accurately all the facts implied in the observed series of monthly means, so that the mean for any one of the calendar months may be derived from it with precision, by integrating ydx between the proper limits for the beginning and end of the month, and dividing by the arc which measures its length. Let the general form,

$$y=a+a_1\sin(x-e_1)+a_2\sin2(x-e_2)+a_3\sin3(x-e_3)+\text{ \&c.},$$

be treated in this way between the limits x' and x'' correspond-

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ing to the beginning and end of a month whose mean is m, and let us make

$$\tfrac{1}{2}(x''-x')=\alpha, \qquad \tfrac{1}{2}(x''+x')=\beta;$$

then the monthly mean will be expressed thus:

$$m=a+a_1\frac{\sin\alpha}{\alpha}\sin(\beta-e_1)+a_2\frac{\sin 2\alpha}{2\alpha}\sin 2(\beta-e_2)+a_3\frac{\sin 3\alpha}{3\alpha}\sin 3(\beta-e_3)+\text{ \&c.}$$

The values of $\frac{\sin\alpha}{\alpha}$, $\frac{\sin 2\alpha}{2\alpha}$, &c., depend only on the length of the month, and their logarithms are given in the subjoined table, for months of all the different lengths.

	Month of 31 days.	Month of 30 days.	February.	Mean months.
$\log\frac{\sin\alpha}{\alpha}$	9·994840	9·995169	9·995719	9·995027
$\log\frac{\sin 2\alpha}{2\alpha}$	9·979214	9·980547	9·982777	9·979971
$\log\frac{\sin 3\alpha}{3\alpha}$	9·952651	9·955722	9·960852	9·954395
$\log\frac{\sin 4\alpha}{4\alpha}$	9·914288	9·919945	9·929367	9·917502
$\log\frac{\sin 5\alpha}{5\alpha}$	9·862723	9·872015	9·887409	9·868005
$\log\frac{\sin 6\alpha}{6\alpha}$	9·795732	9·810048	9·833588	9·803880

The values of the arc β, which measures the time from the beginning of the year to the middle of a month, are for the calendar months

15° 16′ 39″	103° 43′ 54″	193° 55′ 6″	284° 35′ 53″
44 28 25	133 47 38	224 28 25	314 39 37
73 40 10	163 51 22	254 32 9	344 43 21

and for mean months they are 15°, 45°, 75°, &c.

Now in the expression for the monthly mean m, let the constants a, a_1, e_1, a_2, e_2, &c., take those values which have been found for them in the New Haven equation, and the following monthly means for the calendar months may be obtained.

26·530	46·870	71·668	51·093
28·111	57·278	70·313	40·324
36·056	66·949	62·512	30·424

The errors of these computed values as compared with the monthly means actually observed are

·0	+·030	+·008	−·007
+·001	−·002	−·007	+·004
−·034	−·011	+·012	+·004

This example shows the degree of accuracy with which an equation obtained by the method of mean months may be expected to represent any observed series of means for calendar

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months. The reason why the computed values do not agree exactly with the observed ones is, that the curve of the form

$$y=a+a_1 \sin(x-e_1),$$

by means of which my system of twelve equations was obtained, is only an approximation to the true curve for any month, and is not the same as the computed curve whose equation contains twelve constants. The two curves approach each other closely, and intersect at several points, but they do not coincide. They both include the same monthly mean for the mean month, but not for the calendar month. It is probable, however, that no other method of reduction of equal simplicity will give an equation which expresses the means for the calendar months so accurately as this.

It should be noticed that when monthly means of rain-fall are to be corrected for the inequality of the months by my system of equations, the correction must be applied not to the mean *total* amount of rain for any month, but to the mean *daily* amount for that month. Take, for instance, the results of 24 years' observation at Albany, from 1826 to 1849 inclusive, given by F. B. Hough in the "New York Meteorology." The mean total amounts of rain and melted snow and hail for the calendar months, in inches of depth, are

2·91	2·88	4·09	3·76
2·62	4·04	3·44	3·30
3·02	4·50	3·47	2·98

Dividing each of these by the number of days in the month, we have the following values of the mean daily rain-fall, for calendar months, in decimals of an inch:

·0939	·0960	·1319	·1213
·0928	·1303	·1110	·1100
·0974	·1500	·1157	·0961

Now applying the correction, we obtain the mean daily rain-fall for mean months,

·0939	·0968	·1312	·1213
·0929	·1314	·1108	·1098
·0975	·1500	·1158	·0960

and the equation of the curve is found to be

$$\begin{aligned} y=\cdot1123&+\cdot0202 \sin(x-106^\circ\ 43')+\cdot0106 \sin 2(x-107^\circ\ 10') \\ &+\cdot0112 \sin 3(x-14^\circ\ 11')+\cdot0031 \sin 4(x-51^\circ\ 7') \\ &+\cdot0024 \sin 5(x-56^\circ\ 40')+\cdot0015 \sin 6x. \end{aligned}$$

If we assign to x the value appropriate for any given day in the year, the resulting value of y will be the average depth of rain-fall at Albany for that day, expressed in decimals of an inch.

After an equation has been obtained, there ought to be some

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check to show whether it is free from errors of computation. This may be secured by deriving from it the mean for any one of the mean months. When the constants in the Albany equation are transferred to the general expression for the monthly mean, and α and β take the values appropriate for the third mean month for instance, the result is $m = \cdot 0975$; the agreement of this with the daily mean for the third mean month as previously found, is evidence that the equation of the curve has been computed correctly.

January 11th, 1867.

ART. XXXVI.—*Researches on Solar Physics;* by WARREN DE LA RUE, Esq., Pres. R.A.S., BALFOUR STEWART, Esq., Superintendent of the Kew Observatory, and BENJAMIN LOEWY, Esq., Observer and Computer to the Kew Observatory.

Second Series (in continuation of First Series). Area-measurement of the Sun-spots observed by Carrington during the seven years from* 1854–1860 *inclusive, and deduction therefrom.*

34. In our first paper (Art. 13) we stated that Mr. Carrington had very kindly placed at our disposal all his original drawings of sun-spots. Our first step was to arrive at some estimate of the accuracy of these sketches, and we requested Dr. von Bose, who assisted Mr. Carrington in the greater part of his observations, to give us a short outline of the method employed in obtaining them.

From his account, it would appear that the sun's disk was thrown upon a screen, and that each group as represented on the screen was separately drawn on a sheet of paper. The groups on paper were then each separately compared with those on the screen and modified where faulty; and this process was continued until the paper sketches agreed as nearly as possible with the groups on the screen. It would thus appear that very great care was taken with these sketches. [Engravings of several of Carrington's sketches alongside of those of corresponding groups as taken by the Kew Heliograph are given in the original memoir, showing that Carrington has obtained by the method above described a very great accuracy of delineation.]

35. The trustworthiness of Carrington's sun-pictures being thus established, it seemed to us that the labor of measuring for each group the amount of spotted area would be well bestowed, inasmuch as the method hitherto employed, namely, the mere statement of the number of sun-spots occurring at any pe-

* From a memoir printed for private circulation; tables and plates, and many paragraphs omitted. For First Series, see p. 179.

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riod, can only be supposed to afford very approximate means of estimating the extent of solar activity at that period; while, again, if we wish to study the behavior with respect to size of each group as it passes over the visible disk, this can only be done accurately by the laborious but sure method of measurement.

36. *Method adopted in measuring Carrington's groups.*—In order to accomplish this task, the following method was adopted:—In the first place, in order to obtain the apparent area of any group, a piece of plate glass had a number of lines etched upon it, by means of which it was cut up into squares, the side of each square being $\frac{1}{40}$th of an inch. In order to facilitate reading, each fifth line was painted red.

This piece of glass was then applied (the engraved face toward the drawing) to the group whose apparent area it was desired to measure, and the number of squares and fractional parts of a square occupied by the umbra, the penumbra, and the whole spot was *separately* reckoned and noted down. If it was found that the number of squares reckoned for the whole spot was equal to the sum of those reckoned for the umbra and penumbra together, it was concluded that the measurement was correct.

This method of checking the accuracy of the measurement had the further advantage of giving separately the areas of the umbra and penumbra, thus affording determinations which may be made use of in advancing our knowledge of the subject, although not used by us in our present research.

37. But it is evident that after the apparent area of a group has thus been correctly estimated, this apparent area will not indicate the real size of the group, unless allowance is made for the foreshortening occasioned by its angular distance from the visual center of the disk.

[The practical methods by which this allowance for foreshortening was made are given in detail. The final results of the measurements form an extensive table and give the material for a graphical representation of the observed spotted area for each clear day from the beginning of 1854 to the end of 1860.]

40. *Distribution of Spotted Area over Disk.*—Our next inquiry has reference to the relative distribution of spotted area over different parts of the solar disk. We use the word *disk* in contradistinction to *surface*, because it is evident that, on account of the sun's rotation, the center of his visible disk on one day does not represent the same portion of the solar surface as on another day; indeed from this cause it is well known that sun-spots travel over the visible disk from left to right. It is therefore *one* inquiry to study from day to day the relative distribution of spotted area over different parts of the sun's actual surface, and *another* to study the same from day to day over different

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parts of his apparent disk. We have not hitherto attempted the former inquiry (although the subject is not lost sight of, but may come within the range of our future researches), but have confined ourselves entirely to the latter, and now proceed to describe the method of observation adopted.

41. Suppose the visible disk of the sun to be cut up into sections by great circles passing through these poles. These great circles may be regarded as lines of longitude, only, in the present instance, they are not supposed to move round with the sun's surface, but rather to be connected with the earth in such a manner that the plane which passes through the earth is always reckoned the zero or meridian.

Now it is well known that the pole of the sun differs very little from that of the ecliptic, and therefore, in an approximate investigation like the present, we may suppose the two to coincide; these longitudes will thus denote ecliptical longitudes, and the longitude in which the earth is placed being called zero, we may with propriety reckon those to the left negative, and those to the right positive. A sun-spot as it moves across the disk on account of rotation will thus appear at a longitude $-90°$, and vanish at a longitude $+90°$.

The same course will be pursued by the inferior planets Mercury and Venus, which move faster than the Earth; while, on the other hand, the superior planets, which move slower than the Earth, may be supposed to pursue an opposite course, passing across the circles of longitude from right to left.

42. It will thus be apparent that, if the behavior of sun-spots is at all influenced by the positions of the planets, the fact is likely to be discovered by this means. Thus if all the prominent planets be in the same longitude as the Earth, if there be a bond between sun-spots and planets, we should be entitled to expect in such a case some change in appearance or size when the spots for that period pass the central line; if, on the other hand, these planets be together at 20° to the right of the Earth, we might expect some change at 20° to the right, and so on. In fine, one of our objects in the present research is to ascertain the comparative size, at the different ecliptical longitudes in the visible disk, of the whole spotted area for any period, the mass of observations being broken up for this purpose into periods embracing perhaps three or four months, so as to comprehend in each a sufficient number of groups.

43. For this purpose the following plan was adopted. A subsidiary table was formed in which the whole visible disk was portioned out into thirteen parts, each part denoting a day's progress of a spot and embracing every 14° of longitude from $-90°$ to $+90°$. Each of these parts had in this table two columns allotted to it, in one of which the exact longitude of the

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spot (with reference to the earth or central point) was noted, while in the other the area *at this longitude* of the whole spot, including umbra and penumbra, was given. *This longitude* of a spot was determined in the following manner. In each of Carrington's large pictures the position of the sun's axis is given. A circular sheet of transparent tracing-calico, of the size of Carrington's sun, had drawn on it lines of longitude for every 10° from −90° to +90°. This sheet being applied in a proper manner to each of Carrington's pictures, the longitude of a spot was thus at once read off to the nearest degree.

The subsidiary table having been thus formed, it was then carefully examined, and all those groups were rejected for which (either on account of their exceedingly small size and consequently doubtful area, or from paucity of observations) a reasonably good line representing their behavior in passing over the disk could not be obtained. Each non-rejected group was then dealt with in the following manner. A curve was drawn, in which the abscissæ represented the longitudes of the visible disk from −90° to +90°, while the ordinates denoted the corresponding area of the group in millionths of the whole hemispherical surface at each of these longitudes. This curve was formed simply by connecting together by means of straight lines the summits of the consecutive ordinates denoting observed areas. From these curves a table was then formed denoting the probable area of each non-rejected group from longitude −62° to longitude +64°, it being thought inadvisable to go nearer the sun's border on either side. Finally, the groups of this table were arranged into consecutive series, each series embracing two or three months, it being supposed that during the course of any one series the planetary configurations retained to a considerable extent the same character. In the following table the results of this subdivision are exhibited.

[The last two columns have been added from a plate in which the positions of Venus and Jupiter are exhibited in connection with a graphical representation of the series of numbers in the table.]

45. Now, *in the first place*, it is evident that during the time embraced in a series the amount of spotted area which crosses one ecliptical longitude is different from that which crosses another,—that is to say, the average size of a spot varies with the ecliptical longitude. This will be seen from a very cursory glance; thus in series IX, X, the average size of a spot attains a maximum at about the longitude of the earth, while in series XI this maximum is much to the right. Since most of these series embrace a considerable number of spots, this behavior may, we think, be considered to be an observational fact.

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Table exhibiting the area of the non-rejected groups for the different ecliptical longitudes of the visible disk (longitude of Earth =0°).

No. of series.	Average date of series.	Average size of a group in millionths of the hemispherical area at the following longitudes:—										Longitude of Venus.	Longitude of Jupiter.
		−62°	−48°	−34°	−20°	−6°	+8°	+22°	+36°	+50°	+64°		
I.	1854, Mar. 5	81	90	113	155	229	271	311	330	358	366	+ 10	+120
II.	May 20	105	100	96	80	70	77	78	72	57	39	+ 60	+ 50
III.	Nov. 18	225	261	299	299	298	289	243	239	254	246	+170	−110
IV.	1855, Aug. 25	28	24	21	22	32	43	54	73	84	151	− 20	− 10
V.	1856, Aug. 24	73	78	76	79	82	67	84	60	41	33	−150	+ 40
VI.	1857, Mar. 15	88	94	117	125	167	178	206	211	187	158	− 30	−160
VII.	Aug. 16	111	102	107	106	120	128	108	120	130	135	+ 70	+ 80
VIII.	Nov. 7	94	104	124	132	121	110	108	97	88	81	+140	− 10
IX.	1858, Feb. 1	351	378	394	389	392	401	405	374	325	261	+160	− 80
X.	Apr. 26	141	192	240	295	343	367	365	361	304	211	−120	−140
XI.	July 17	111	118	147	162	173	199	224	238	261	264	− 90	+120
XII.	Nov. 8	231	255	288	316	330	337	349	370	394	418	− 40	+ 30
XIII.	1859, Mar. 8	..	240	229	233	228	218	221	222	197		+ 60	− 70
XIV.	June 22	145	136	128	118	107	100	91	83	79	75	+130	+170
XV.	Aug. 5	342	353	372	405	426	429	414	415	413	410	+150	+150
XVI.	Nov. 11	175	183	195	203	213	226	227	223	213	205	−160	+ 60
XVII.	1860, Feb. 24	123	140	157	168	182	200	195	180	173	161	− 90	− 40
XVIII.	May 16	100	122	141	165	175	185	181	186	184	180	− 30	−110
XIX.	July 2	313	326	321	306	284	271	272	288	251	241	− 10	−160
XX.	Oct. 12	210	225	254	263	255	251	243	221	214	191	+ 60	+110

46. *In the second place*, there seems to be a periodical recurrence of the same sort of behavior. Thus in series I, IV, VI, (XI and XII), XVIII, there is a maximum considerably to the right. The mean dates of these series are:—

I, March, 1854 ....
IV, August, 1855 ....
VI, March, 1857 ....
XI and XII, July to Nov. 1858
XVIII, May, 1860 .....

hence

.....IV=I+17 months.
..... VI=IV+19 "
... (XI and XII)=VI+18 "
XVIII=(XI and XII)+20 "

Mean period, 18·5 "

Also in series II, (after IV), VIII, (XIII and XIV), (XIX and XX), there is a maximum considerably to the left. The dates of these series are:—

II, May, 1854.....
after IV, (say) Dec. 1855 ...
VIII, November, 1857...
(XIII and XIV), March to June 1859, ...
(XIX and XX), July to Oct. 1860

hence

.....IV=II+19 mos.
..... VIII=IV+23 "
.... (XIII and XIV)=VIII+18 "
(XIX & XX)=(XIII & XIV)+15 "

Mean period, 19 "

Again, in series III, V, (IX and X), (XV, XVI, and XVII) the maximum is not far from the center. The dates are:—

III, November, 1854 ..
V, August, 1856.....
(IX and X), Feb. to April, 1858
(XV, XVI, XVII) Aug. 1859 to Feb. 1860..

hence

.....V=III+21 mos.
..... (IX and X)=V+19 "
(XV, XVI, XVII)=(IX, X)+20 "

Mean period, 20 "

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Finally, in series IV, VII, XIII, and XIX we have probably a minimum near the center accompanied with a somewhat undecided action. The dates of these series are:—

IV, August, 1855.....	hence	.....VII=IV+24	months.
VII, August, 1857.....		.....XIII=VII+19	"
XIII, March, 1859		.....XIX=XIII+16	"
XIX, July, 1860		Mean, 20	"

The period of recurrence of the same behavior would thus appear to be nineteen or twenty months.

47. *In the third place*, in all these recurrences the progress of the maximum is from left to right, *not* right to left. Thus in series III the maximum is near the center, while in series IV it has gone to the right. The same order is observable in series X and XI, and in fact, throughout the whole twenty series.

48. We cannot see that these phenomena can possibly be explained, unless it be admitted that the behavior of the sun-spots is subject to some external influence, the nature of which will best be determined by the order of recurrence and length of period of the phenomena in question.

In the first place, it is clear that the influence is not stationary, otherwise its period would be one year, that being the time in which the earth (which must be regarded as the standpoint from which these phenomena are viewed) accomplishes one revolution round the sun. Again, since the march of the phenomena is from the left to the right of the earth, this would seem to identify the influence with one of the inferior planets which passes over the sun's disk in this direction (Art. 41), the superior planets going the opposite way.

The period of twenty months will now enable us to determine which of the inferior planets exercises the predominent influence on sun-spots. We have to ask which of the two inferior planets takes twenty months to return to the same position with respect to the earth. This evidently points to Venus, for which the synodical period is 583 days, or between nineteen and twenty months. We may remark that, apart from all observation, if we suppose the various planets to affect the behavior of sun-spots, the influence of Venus should be very great, on account of its nearness to the sun combined with its very considerable size. An examination of the table on p. 326 will give us some idea of the nature of the influence probably exerted by Venus. The average size of a spot would appear to attain its maximum on that side of the sun which is turned away from Venus, and to have its minimum in the neighborhood of this planet.

But, it will be asked, does not Jupiter appear to exert any influence? for although its distance is much greater than that of Venus yet its mass is very great. A reference to the table will,

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we think, show that the influence of Jupiter is very great, although not apparently predominating. Thus when Venus and Jupiter are both in opposition to the earth, we might expect a very large average size of spots at the longitude of the earth; but if, Venus being in opposition, Jupiter is in conjunction with the earth, the average size ought to be much smaller. In series X and XV the former is the case, and for these the average size of a spot is exceptionally large. In series V, VIII, and XVI the latter is the case, and for these the average size of a spot is exceptionally small.

We ought here to remark that, although Venus has *apparently* a predominating influence, it may not have so in reality; for it is clear that by the method of observation employed, the effect of Jupiter is more equalized than that of Venus, the former separating from the earth or point of view more rapidly than the latter. Thus, if at the beginning of three months' observation Jupiter were in opposition, it would at the end be 96° distant from the earth,—that is to say, its angular motion with respect to the earth during this period would have been nearly 84°, whereas the angular motion of Venus with respect to the earth under similar circumstances would be only 54°. Thus the effect of Venus during this period would be more nearly equal to the maximum effect of Venus than the effect of Jupiter would be to its maximum effect.

[Having thus endeavored to trace the effect of these two planets on the behavior, with respect to size, of sun-spots in crossing the visible disk, the authors supplement the evidence by means of a curve, exhibiting from month to month the whole amount of spotted area for the whole disk. It is evident that in such a curve we ought to have a high point or great amount of area when Venus is in opposition to the earth; in such a case our *standpoint* is favorable. But, again, we ought to have a maximum when the two influential planets, Venus and Jupiter, unite together in acting upon the sun, even although the standpoint of the earth may not be in the most favorable position. The various maxima of such a curve ought thus to be referable to one of two causes, or to both combined—(1) either to a favorable position of the standpoint, or (2) to a favorable conjunction of planets for action upon the sun. The maxima are shown to be in fact regulated by planetary configurations, and especially by the two causes named.]

50. While the preceding portion of this paper was being printed, a circular issued by Mr. Chacornac has been the means of calling our attention to Carrington's diagram exhibiting the distribution of spotted area in heliographical latitude from time to time, and to the minor fluctuations which occur in his diagram.

We had previously proposed to ourselves a complete investi-

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gation into this as the subject of a third series of these researches; but a preliminary investigation of Carrington's diagram has led us to a conclusion which we think of sufficient importance to communicate at once, reserving a more elaborate and accurate investigation to a future occasion.

We think it will very likely be found that, at those periods when the planets Jupiter and Venus cross the solar equator, there will be a tendency of the spotted area to approach the equator, and at those periods when the heliographical latitude of these planets is greatest there will be a tendency for spots to spread out from the solar equator.

Reserving the action of Jupiter to a more complete investigation, we have derived the following result regarding the action of Venus from an approximate method of treating Carrington's diagram. *It would appear that spots are nearest to the solar equator when the heliographical latitude of Venus is* 0°, *and are most distant from the solar equator when this planet attains its greatest heliographical latitude.*

51. *Concluding remarks.*—The following question may occur to our readers, How is it possible that a planet so far from the sun as Venus or Jupiter can cause mechanical changes so vast as those which sun-spots exhibit? We would reply in the following terms to this objection.

We do not, of course, imagine that we have as yet determined the nature of the influence exerted by these planets on the sun; but we would, nevertheless, refer to an opinion expressed by Professor Tait, "that the properties of a body, especially those with respect to heat and light, may be influenced by the neighborhood of a large body." Now an influence of this kind would naturally be most powerful upon a body such as the sun, which possesses a very high temperature, just as a poker thrust into a hot furnace will create a greater disturbance of the heat than if thrust into a chamber very little hotter than itself. In the next place, it is not to be inferred that the mechanical equivalent of the energy exhibited in sun-spots is derived from the influencing planet any more than it is to be inferred that the energy of a cannon-ball is derived from the force with which the trigger is pulled.*

The molecular state of the sun, just as that of the cannon or of fulminating powder, may be extremely sensitive to impressions from without; indeed we have independent grounds for supposing that such is the case. We may infer from certain experiments, especially those of Cagniard de Latour, that at a very high temperature and under a very great pressure the latent heat of vaporization is very small, so that a comparatively small

* It is, however, a possible inquiry whether these phenomena do not imply a certain loss of motion in the influencing planets.

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increment of heat will cause a considerable mass of liquid to assume the gaseous form, and *vice versâ*. We may thus very well suppose that an extremely small withdrawal of heat from the sun might cause a copious condensation; and this change of molecular state would, of course, by means of altered reflection, &c., alter to a considerable extent the distribution over the various particles of the sun's surface of an enormous quantity of heat, and great mechanical changes might very easily result.

Again, although we cannot suppose our earth to be nearly so sensitive as the sun, yet the question may be entertained, Does the moon exert an influence of this kind upon the earth?

52. Our readers will, we think, agree with us in dividing the results of this paper into three classes.

We have, *in the first place*, the pure results of observation.

In the second place, we have put forth as an immediate deduction from these observational results a connection between sun-spots and planets. The evidence in favor of this deduction appears to us to be very strong, and we have placed it before our readers in detail that every one may judge for himself.

In the third place, we have, in paragraph 50, ventured to adopt an hypothesis regarding the nature of this action, which must, in the meantime, be considered as a working hypothesis, which may, perhaps, serve to extend our knowledge of the subject.

53. A few words may be allowed us with regard to the history of this question. Professor Wolf has, it is well known, directed attention to a probable connection between sun-spots and planets, derived from the periodicity of the former. With regard to his success in this matter we do not venture to give an opinion; we would only remark that our evidence is of a different nature to that which is capable of being derived from periodicity in the number of spots.

Since our preliminary research into the behavior of sun-spots, a suggestion of the illustrious Galileo, which he appears not to have published from want of evidence, has been brought to our notice by the Rev. William Selwyn. This suggestion advocates a method of research allied to that which we have pursued, and we should be happy to think that our present investigation has tended in any measure to vindicate the sagacity of that renowned philosopher. We venture to think that we have succeeded in demonstrating the great probability of planetary influence, and to hope that this probability may be converted into a certainty, and the subject very far advanced before the next ten-yearly maximum, by the labors in solar photography of the Kew Observatory and other similar institutions.

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ART. XXXVII.—*Research on the Ethers of Silicic Acid;* by C. FRIEDEL and J. M. CRAFTS.

[Concluded from p. 171.]

The first distillations were made in vacuo (3–5 millimeters pressure), and the substance used consisted in residues from various preparations of the normal silicate, and of the hexethylic disilicic silicate; both these products had as far as possible already been extracted.

After eight distillations we obtained—

at 60°–115° (Centigrade.)	6 grs.	of liquid.	
115 –135	16 "		
135 –150	8 "		
150 –165	14 "		
165 –180	30 "	Si=18·73	per ct.
180 –200	16 "	Si=19·58	"
200 –220	8 "	Si=20·78	"
220 –260	4 "	Si=21·96	"
260 –300	3 "	Si=22·78	"
300 –320	3 "	Si=23·59	"

The largest portion within narrow limits of temperature, that which distilled 165°–180°, was redistilled in the air; it commenced to distill at 285°, and between this point and 305°, 25 grs. of liquid passed; above 305° there were only 8 grs. This last product contained 19·34 per cent Si.

All the products distilled above, except those which had passed at a temperature higher than 200° in vacuo, were redistilled under the ordinary pressure. There was obtained on the 6th distillation,

175°–215°	6·5 grs.	
215 –235	6.5 "	
235 –243	25·0 "	=hexethylic disilicic ether.
243 –260	10·0 "	
260 –276	15.0 "	
276 –286	10·0 "	Si=17·85 per ct.
286 –294	12·0 "	Si=18·22 "
294 –310	5·0 "	
	90·0	

The portion of the above products containing the more condensed ethers, i. e., the part boiling 243°–310°, was redistilled under a pressure of 58–60mm. ($=\frac{1}{12}$ the ordinary pressure of the air), until the amount of liquid distilling at a given point remained nearly constant in successive distillations.

There was obtained—

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	4th distillation.	5th distillation.	
170°–195°	7·0 grs.	6·5 grs.	
195 –205	10·0 "	9·5 "	Si=18·26 p. c.
205 –215	7·0 "	7·0 "	
215 –230	8·5 "	9·2 "	
230 –240	6·0 "	5·0 "	Si=19·50 p. c.
240 –285	7·0 "	6·8 "	
	45·5	44·0	

The portion distilling above 200° in vacuo, and that which distilled above 285° under a pressure 58–60 mm., were redistilled three times under a pressure of 9–10 mm.

220°–235°	5·0 grs.	Si=20·60, C=37·01, H=7·64 p. c.
235 –245	2·2 "	Si=20·99 per ct.
245 –280	6·0 "	Si=21·40 "

Finally, the portion remaining above 280°, was distilled under a pressure of 1–3mm.

270°–320°	1·0 grs.	
320 –360	3·0 "	Si=22·79 per ct.
above 360	2·1 "	Si=23.91 "

The formula of Ebelmen's bisilicate requires 20·90 per ct. Si. The quadrisilicate 28·66 per ct. Si.

We made other distillations of the higher products in vacuo, analyzing the liquid, which passed at different temperatures, and found the results to agree with the foregoing.

Thus after a very prolonged series of fractionated distillations, we not only failed to obtain the bisilicate among the products distilling in the neighborhood of its supposed boiling point, but we also failed to isolate any body having a definite composition and a constant boiling point. The proportion of silica in these condensed ethers increases with the temperature, at which they distill, while that of carbon and hydrogen diminishes, and the relations between these constituents do not lead to any simple formula. Products from different preparations having the same boiling points have nearly the same composition.

It is probable that there are several condensed silicates belonging to some of the types mentioned (p. 166) and that they can not be separated by distillation. It is worthy of notice that in all the bodies analyzed the ratio of carbon to hydrogen is the same as in the radical ethyl.

We also attempted to prepare the bisilicate by following exactly the method given by Ebelmen, but failed to obtain it, either because some precaution was omitted in repeating his experiments, or because the bisilicate does not exist. We will observe that the method of preparation given (distillation without thermometer, above the boiling point of mercury) does not offer a very good guaranty for the purity of the substance.

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Silicates of methyl.—When we commenced our research, we tried the reaction of methylic alcohol on the chlorid of silicium; but like Ebelmen* we only obtained a product, that it was impossible to purify, turning brown in the air and possessing a fetid odor. We noticed, that this product always contained chlorine.

After having observed that the radicals contained in the alcohols may replace those contained in the ethers of acids† we thought that this reaction might furnish a method of obtaining the silicate of methyl.

With this object, we purified wood-spirit by a treatment with chlorid of calcium, and after decomposing the chlorid of calcium compound with water and rectifying the alcohol several times with sodium, we sealed it in a tube with silicate of ethyl, and heated the mixture during 20 hours at 210°.

After several fractionated distillations the principal product, isolated from the contents of the tube, was a liquid boiling at 143°–147°, together with products with a much higher boiling point.

The portion boiling at 143°–147° gave on analysis numbers which correspond with the composition of a mixed silicate diethylic dimethylic silicic ether.

I.	Substance, weight, - - - -	0·3035 gr.
	$C\Theta_2$, - - - - - -	0·4320 "
	$H_2\Theta$, - - - - - -	0·2435 "
II.	Substance, weight, - - - -	0·3450 "
	$Si\Theta_2$, - - - - - -	0·1150 "
III.	Product redistilled, 143°–147°.	
	Substance, weight, - - - -	0·2220 "
	$C\Theta_2$, - - - - - -	0·3250 "
	$H_2\Theta$, - - - - - -	0·1840 "
IV.	Another preparation, portion distilling, 145°–147°	
	Substance, weight, - - - -	0·2900 "
	$C\Theta_2$, - - - - - -	0·4315 "
	$H_2\Theta$, - - - - - -	0·2350 "

	I.	II.	III.	IV.	Theory. $Si\Theta_6H_{16}\Theta_4$.
C,	38·90		39·89	40·61	40·00
H,	8·94		9·20	9·00	8·88
Si,		15·51			15·55

It is remarkable, that in these experiments the principal product formed, and the only one that was easy to isolate, was this mixed ether, and not the silicate of methyl or the trimethylic mono-ethylic ether, although the methylic alcohol was used in large excess.

* Ann. de Chim. et Phys., [3], xvi, 129. † This Journal, [2], xl, 34.

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In an experiment, made with the special object of obtaining an ether containing a larger proportion of methyl, we heated silicate of ethyl during 15 hours at 250° with a large excess of methylic alcohol, then distilled, and heated a second time with methylic alcohol, the liquid, boiling below 150°, but still the greater part of the product passed at 143°–147°. This product redistilled at 145°–147° furnished us the material for analysis No. IV. If the mono-methylic and mono-ethylic mixed ethers are formed, as is probable, it is in a much smaller proportion.

The simultaneous production of condensed ethers with a higher boiling point, noticed above, could only be accounted for by the presence of water in the methylic alcohol used, since we convinced ourselves by experiment, that there was no formation of ordinary methylic or ethylic ether, bodies whose production would equally have accounted for the formation of condensed silicates. The methylic alcohol really loses water by the process; for on employing the same alcohol for a second preparation, there was production of more of the mixed ethers and less of the condensed silicates.

This observation induced us to give greater attention to rendering the methylic alcohol anhydrous; and we discovered, that even 8–10 distillations with sodium and methylate of sodium were not sufficient to make the alcohol perfectly anhydrous. It is probable, that when the percentage of water is reduced to a certain limit, the methylate of sodium is no longer decomposed.

We were more successful in drying methylic alcohol by means of anhydrous phosphoric acids.

Methylic alcohol, distilled twice with sodium, and then with a small quantity of phosphoric acid, boils at 65°·5, loses the disagreeable odor, that it usually has, and smells like common alcohol, and does not turn brown with soda. Purified in this manner, it no longer gives, when heated with silicic ether, more than traces of condensed silicates.

The preceding observations on the difficulty of purifying and drying methylic alcohol led us to suspect, that the bad success of the attempts of Ebelmen and our own to obtain methylic silicic ether by the direct action of chlorid of silicium on the alcohol, arose merely from the impurity of the material employed. The following experiment shows, that this was the case.

Methylic alcohol, purified with the precautions mentioned above and added in small quantities at a time to chlorid of silicium, reacts upon it in exactly the same manner as ordinary alcohol. It does not turn brown more than the latter. Hydrochloric acid is given off in abundance, reducing the temperature of the liquid. When the theoretical quantity of alcohol has been added, the product is distilled, and after a small number

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of fractionated distillations, it is easy to separate two principal products, one boiling at 120°–122°, and the other at 201°–202°·5. The first product is almost the only one formed, where the alcohol is perfectly anhydrous; it is the normal silicate of ethyl. The second is the hexamethylic disilicic ether.

The products, obtained in the first preparations, were not entirely pure, and analysis showed that a small quantity of an ethylic compound was present; it therefore became necessary to employ a methylic alcohol, obtained by saponification of the oxalate, and all the preparations were subsequently made with this product rectified successively with sodium and phosphoric acid.

In one operation, made with a portion of methylic alcohol, which had been heated with silicate of methyl in a sealed tube, an excellent means of rendering it quite anhydrous, the whole product of the reaction distilled at 121°–126°. Of this the portion boiling at 121°–122° was analyzed.

I.	Substance, weight,	0·3400 grs.
	CO_2,	0·3930 "
	H_2O,	0·2440 "
II.	Substance, weight,	0·9275 "
	SiO_2,	0·3680 "

This product contained $\frac{27}{100}$ of a per cent of chlorine and we found, that the only way to free the methylic ethers completely from chlorine (probably contained in a chlorhydrine) is to heat them in a sealed tube at 180° with an excess of methylic alcohol. After this treatment the product was distilled again at 121°–122° and on analysis gave:

III.	Substance, weight,	0·2800 grs.
	CO_2,	0·3255 "
	H_2O,	0·2005 "
IV.	Substance, weight,	0·4025 "
	SiO_2,	0·1610 "

	I.	II.	III.	IV.	Theory. $Si(CH_3)_4O_4$.
C,	31·56		31·68		31·58
H,	7·98		7·95		7·89
Si,		18·52		18·57	18·42

The density of vapor =5·380. The theory requires 5·264.

Difference between 2 weights of bulb,	0·9730 gr.
Temperature of the balance,	20°
" " oil bath,	190°
Height of barometer,	760 mm.
Capacity of bulb,	333·5 cc.
Air remaining,	0·2 cc.

The density of the ether at 0°=1·0589.

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The normal silicate of methyl is a colorless liquid, possessing an etheric and rather agreeable odor. It is soluble in considerable quantity in water, and the solution only gives a gelatinous deposit of silica at the end of some weeks. Moisture or aqueous alcohol decomposes it rapidly with formation of condensed products and ultimately of silica. It burns with a white smoke composed of silica.

Hexamethylic disilicic ether is formed, whenever the normal ether is prepared with aqueous alcohol, and it may also be obtained by heating the normal ether with methylic alcohol containing water. It boils, as we have already said, at 201°–202°·5, and resembles the hexethylic disilicic ether very much in its properties.

An analysis gave—

I.	Substance, weight,	0·2880 gr.
	CO_2,	0·2960 "
	H_2O,	0·1800 "
II.	Substance, weight,	0·5655 "
	SiO_2,	0·2665 "

III. Product remaining in the bulb after the determination of the vapor-density.

Substance, weight,	0·3335 gr.
CO_2,	0·3400 "
H_2O,	0·2100 "

	I.	II.	III.	Theory. $Si_2(CH_3)_6O_7$.
C,	28·04		27·80	27·90
H,	6·95		6·99	6·97
Si,		22·00		21·70

The vapor density =9·19. The theory requires 8·93.

Difference of 2 weights of bulb,	1·2422 gr.
Temperature of balance,	24°
" " oil bath,	266°·5 mercury therm.
" " " "	263° air thermometer.
Barometric height,	759·1 mm.
Capacity of bulb,	253·25 cc.
Air remaining,	0·2 cc.

The density of this ether at 0°=1·144.

We have not succeeded in isolating any product of a definite composition with a boiling point higher than that of the hexamethylic disilicic ether, and the result of our experiments has been exactly the same as in the case of the ethylic condensed ethers. The per-centage amount of silicic acid rises with the boiling point. We did not extend our investigations so far as was done with ethylic ethers.

We call attention to the small difference in the boiling points of the methylic and ethylic normal silicate =44°, only 11° for

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each difference of CH_2. The difference in the case of methylic and ethylic-disilicic ethers is 33° or 5½° for each difference of CH_2.

The monochlorhydrine of the normal methylic silicic ether was obtained, in the same way as the ethylic chlorhydrine, by heating together during one hour at 150°, three molecules of the ether with one molecule of chlorid of silicium. Almost the whole product boiled at 113°–117° and after several distillations the portion boiling at 114°·5–115°·5 gave on analysis—

I.	Substance, weight,	0·5965 gr.
	SiO_2	0.2295 "
II.	Substance, weight,	0·2695 "
	CO_2,	0·2305 "
	H_2O,	0·1420 "
III.	Substance, weight,	0·7255 "
	AgCl,	0·6625 "

	I.	II.	III.	Theory. $SiCl(CH_3)_2O_2$.
C,		23·31		23·00
H,		5·85		5·75
Si,	17·95			17·89
Cl,			22·59	22·68

The density of vapor =5·578. Theory 5·420.

Difference between 2 weights of bulb,	1·2147 gr.
Temperature of the balance,	19°
" " oil bath,	170°·5
Barometric height,	766·5 mm.
Capacity of bulb,	369·5 cc.
No air remaining.	

The density of the liquid at 0°=1·1954.

The monochlorhydrine is a liquid with an etheric odor, burning with a green chlorine flame and giving off a siliceous smoke. It is very easily decomposed by moisture. With methylic alcohol it regenerates the normal methylic silicate. It will be seen in the sequel, that the chlorhydrine can be used for the preparation of mixed ethers.

The Dichlorhydrine of methylic-silicic ether was obtained by heating two molecules of monochlorhydrine with one molecule of chlorid of silicium during one hour at 160°. The reaction is somewhat less easy than in the case of the formation of the monochlorhydrine. The larger part of the product distilled at 98°–103°, and the liquid obtained, boiling at this temperature, after four distillations was analyzed.

I.	Substance, weight,	0·2565 gr.
	CO_2,	0·1400 "
	H_2O,	0·0855 "

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II.	Substance, weight,	0·4480 gr.
	SiO_2,	0·1700 "
III.	Substance, weight,	0·9325 "
	AgCl,	0·1669 "

	I.	II.	III.	Theory. $Si,Cl_2,(CH_3)_2O_2$.
C,	14·85			14·90
H,	3·70			3·72
Si,		17·68		17·39
Cl,			44·28	44·10

Density of vapor = 5·66. Theory 5·57.

Difference between 2 weights of bulb,	0·8755 gr.
Temperature of balance,	20°
" " oil-bath,	182°·5
Barometric height,	761·4 mm.
Capacity of bulb,	272·75 cc.
Air remaining,	0·5 cc.

The density of liquid at 0° = 1·2595. The physical properties of the dichlorhydrine resemble those of the monochlorhydrine.

The Trichlorhydrine of the methylic-silicic ether was obtained by heating one molecule of chlorid of silicium with one molecule of the dichlorhydrine during twelve hours at 220°. It is formed much less easily than the preceding bodies; even after the tube had been heated so long a time, a portion of the chlorid of silicium remained intact. The principal product distilled at near 84°. After several fractionated distillations, the portion boiling at 82°–86° was separated and analyzed.

I.	Substance, weight,	0·2980 gr.
	CO_2,	0·0800 "
	H_2O,	0·0485 "
II.	Substance, weight,	0·2510 "
	SiO_2,	0·0920 "
III.	Substance, weight,	0·4105 "
	Cl,	0·0700 "

	I.	II.	III.	Theory. $SiCl_3CH_3O$.
C,	7·29			7·25
H,	1·81			1·81
Si,		17·05		16·92
Cl,			64·46	64·35

Vapor density = 5·66. Theory, 5·73.

The density was taken by the method of Gay Lussac.

Weight of substance employed,	0·445 gr.
Temperature of the oil-bath,	134°·5 "
Volume of vapor,	109·0 cc.
Height of barometer,	759 mm. at 23°·5
Height of the mercury in the bell glass above the level of the mercury in bath,	128·2 mm.

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Mixed methylic-silicic ethers.—Where the chlorhydrines are treated with an alcohol, they exchange the Cl, for the radical of the alcohol and Θ, and in this manner, by employing different alcohols, mixed normal ethers may be obtained. Ordinary alcohol reacts immediately on the monochlorhydrine with evolution of HCl, and the principal product is trimethylic monoethylic-silicic ether. No chlorhydrine remains undecomposed, and there is no formation of silicate of ethyl, and after the excess of alcohol has distilled, the liquid commences to boil at 133°. There is also a small quantity of a product with a boiling point which corresponds to that of the dimethylic diethylic ether formed.

The product boiling at 133°–135 gave on analysis—

I.	Substance, weight,	0·2890 gr.
	$SiΘ_2$,	0·1060 "
II.	Substance, weight,	0·2450 "
	$CΘ_2$,	0·3240 "
	$H_2Θ$,	0·1885 "

	II.	I.	Theory. $Si(CH_3)_2(C_2H_5)_2,Θ_4$.
C,	36·03		36·14
H,	8·55		8·43
Si,		17·14	16·86

The density of the liquid at 0°=1·0230.

In order to explain to ourselves the formation of the dimethylic diethylic silicic ether, we examined the alcohol, which distilled after the completion of the reaction.

It distilled in great part at 72°–74°. It was treated with powdered caustic potash to remove the hydrochloric acid it contained in solution, distilled and then left over night in contact with freshly calcinated carbonate of potash.

An analysis of this alcohol gave,

Substance, weight,	0·1995 gr.
$CΘ_2$,	0·3000 "
$H_2Θ$,	0·2250 "

		$CH_4Θ$.	$C_2H_6Θ$.
C,	40·94	37·5	52·17
H,	12·53	12·5	13·04

Common ethylic alcohol containing 21 p. c. of water would have the same composition; but we ascertained that, when aqueous alcohol was treated in the same way with carbonate of potash, it marks 96 p. ct. on the alcoholometer of Gay-Lussac. The alcohol contained a certain quantity of methylic alcohol, which could only have been formed by direct elimination from the methylic-silicic ether with production of an ether, containing a larger proportion of the radical ethyl. We have before observed, that the dimethylic disilicic ether is the one most readily produced.

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This had already been obtained by the action of methylic alcohol on the normal silicate of ethyl.* It is also produced, when the methylic dichlorhydrine is treated with ethylic alcohol.

A product, obtained in this way, and boiling at 143°–146°, was analyzed.

I.	Substance, weight, - - - -	0·2700 gr.
	SiO_2, - - - - - -	0·0910 "
II.	Substance, weight, - - - -	0·2400 "
	CO_2, - - - - - -	0·3485 "
	H_2O, - - - - - -	0·1910 "
III.	Substance, weight, - - - -	0·3635 "
	SiO_2, - - - - - -	0·1225 "

	I.	II.	III.	Theory. $Si(CH_3)_2(C_2H_5)_2,O_4$.
C,		39·56		40·00
H,		8·83		8·88
Si,	15·73		15·71	15·55

The product used in analysis No. III was that which remained in the bulb after a determination of vapor-density.

Density of vapor = 6·178. Theory 6·233.

Difference between 2 weights of bulb, -	0·9569 gr.
Temperature of balance, - - -	21°·5
" " oil-bath, - - -	192°
Height of barometer, - - - -	763·7 mm.
Capacity of bulb, - - - -	279·75 cc.
Air remaining, - - - - -	5·25 cc.

The density of liquid at 0° = 1·004.

The monoethylic triethylic ether, was obtained by treating the monochlorhydrine of the normal ethylic silicate with methylic alcohol.

It boils at 155°–157°.

I.	Substance, weight, - - - -	0·3945 gr.
	SiO_2, - - - - - -	0·1180 "
II.	Substance, weight, - - - -	0·2325 "
	CO_2, - - - - - -	0·3640 "
	H_2O, - - - - - -	0·1925 "

	I.	II.	Theory. $SiCH_3,(C_2H_5)_3,O_4$.
C,		42·71	43·30
H,		9·21	9·28
Si,	13·96		14·43

We repeated with the alcohol, that distilled, the same experiment, that was made, where the monoethylic trimethylic ether

* See page 158.

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was prepared, and we found ethylic alcohol mixed with the portion of methylic alcohol, which distilled 73°–77°.

I.	Substance, weight,	0·1710 gr.
	$\text{C}\Theta_2$,	0·2780 "
	$H_2\Theta$,	0·0955 "
II.	Substance, weight,	0·1545 "
	$\text{C}\Theta_2$,	0·2520 "
	$H_2\Theta$,	0·1790 "

	I.	II.	$\text{C}H_4\Theta$.	$\text{C}_2H_6\Theta$.
C,	44·34	44·51	37·5	52·17
H,	12·69	12·89	12·5	13·04

Therefore in this case there is a replacement of ethyl by methyl in the ether with formation of ethylic alcohol and the dimethylic silicic ether, and doubtless the presence of a small quantity of this latter body explains the small amount of carbon and hydrogen found in the analysis of the monomethylic triethylic silicic ether.

Dimethylic diamylic silicic ether.—In the reaction of amylic alcohol on the monochlorhydrine of methylic ether, the displacement of one alcoholic radical by another was still more strongly marked, for the principal product was a liquid boiling at 225°–235°, which did not have the composition of the trimethylic monoamylic ether, but very nearly that of the dimethylic diamylic ether.

An analysis of this product gave—

I.	Substance, weight,	0·2425 gr.
	$\text{C}\Theta_2$,	0·4780 "
	$H_2\Theta$,	0·2375 "
II.	Substance, weight,	0·3795 "
	$Si\Theta_2$,	0·0865 "

	I.	II.	Theory. $Si(\text{C}H_5)_2(\text{C}_5H_{11})_2\Theta_4$.
C,	53·76		54·55
H,	10·89		10·61
Si,		10·64	10·61

The decomposition of this ether cannot be effected by an alcoholic solution of ammonia, and it is necessary to employ an alcoholic solution of soda for the determination of the silica.

In the production of this ether by the above reaction, we again notice the tendency to the production of mixed ethers containing two atoms of each alcoholic radical.

It should be noticed, that action of an alcohol upon an ether with interchange of alcoholic radicals, seems to take place more readily at the moment of the formation of the ethers from a chlorhydrine, than after the ether has been once formed.

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The Actions of the Anhydrids of Acids on Silicic Ether.—After having observed the substitution of one alcoholic radical for another in ethers, we determined to try to obtain by a similar reaction the replacement of an alcoholic radical by one contained in an acid. The first experiment made was that of heating the chlorid of acetyl with silicic ether, but we have already stated that the chlorine, and not the acetyl, was introduced into the ether with formation of a monochlorhydrine and of acetate of ethyl.

It next occurred to us to try the action of anhydrous acetic acid, $\left.\begin{matrix}\text{Є}_2\text{H}_3\text{Θ}\\ \text{Є}_2\text{H}_3\text{Θ}\end{matrix}\right\}\text{Θ}$, and we found, that by means of this reagent an acetine $\text{Si}(\text{C}_2\text{H}_5)_3, (\text{Є}_2\text{H}_3\text{Θ}), \text{Θ}_4$ could be formed.

35 grams of the normal silicate of ethyl and 13 grams of anhydrous acetic acid, boiling at 138°·5–140°,* were heated during 14 hours at 180°.

After 8 fractionated distillations, the following series of products was obtained—distilled—

77°– 80°	7·0	grs.
80°– 95°	2·5	"
95°–165°	4·0	"
165°–177°	3·0	"
177°–181°	2·5	"
181°–192°	5·0	"
192°–197°	2·5	"
197°–204°	1·25	"
204°–230°	1·6	"
above 230°	5·0	"
	33·75	

The first product, 77°–80°, was acetate of ethyl. According to the theory represented by the equation:

$$\left.\begin{matrix}\text{Si}\\(\text{Є}_2\text{H}_5)_4\end{matrix}\right\}\text{Θ}_4+\left.\begin{matrix}\text{Є}_2\text{H}_4\text{Θ}\\ \text{Є}_2\text{H}_3\text{Θ}\end{matrix}\right\}\text{Θ}=\left.\begin{matrix}\text{Si}\\(\text{Є}_2\text{H}_5)_3\\ \text{Є}_2\text{H}_3\text{Θ}\end{matrix}\right\}\text{Θ}_4+\left.\begin{matrix}\text{Є}_2\text{H}_3\text{Θ}\\ \text{Є}_2\text{H}_5\end{matrix}\right\}\text{Θ},$$

11·2 grs. of acetate of ethyl ought to have been produced. About 9 grs. of pure acetate were really obtained.

The products boiling higher were analyzed.

I.	177°–181°—Substance, weight,	0·2420 gr.
	ЄΘ_2,	0·3900 "
	$\text{H}_2\text{Θ}$,	0·1970 "
II.	178°–182°—Substance, weight,	0·3190 "
	SiΘ_2,	0·0875 "

This product was obtained by redistilling No. I.

* A convenient way of obtaining anhydrous acetic acid is, after rectification on acetic of potash, to rectify on the alloy of zinc and sodium, until the disengagement of hydrogen has become very slight.

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III. (obtained by redistilling 181°–192°)
Substance, boiling 183°–193°, weight, 0·2865 gr.
$\text{Є}\Theta_2$, - - - - - - - 0·4580 "
$H_2\Theta$, - - - - - - - 0·2365 "

IV. 192°–197° Substance, weight, - 0·2790 "
$\text{Є}\Theta_2$, - - - - - - - 0·4400 "
$H_2\Theta$, - - - - - - - 0·2005 "

	I.	II.	III.	IV.	Theory. $\text{Si}(\text{Є}_2H_5)_3(\text{Є}_2H_3\Theta)\Theta_4$
C,	43·94		43·57	42·94	43·24
H,	9·06		9·09	7·99	8·11
Si,		12·80			12·61

The decomposition of the acetine by the alcoholic solution of ammonia is not complete, and an alcoholic solution of soda must be used to make the silicic determination.

The preceding analyses show, that the boiling point of the monoacetine $\text{Si}, (\text{Є}_2H_5)_3, \text{Є}_2H_3\Theta, \Theta_4$ must be near 190°; but we did not succeed in isolating a pure product by distillation. By the action of potash on the acetine, acetic acid is obtained, showing, that it is really an acetine, which is formed. The acetine is a somewhat oily liquid having an ethereal odor, with something of that of acetic acid in it. The odor of acetic acid becomes stronger, when the acetine has been exposed to the action of moisture.

The product of another operation was distilled under a pressure of only 52 millimeters of mercury, because we feared, that the compound might be decomposed by distillation at a high temperature. The liquid boiling at 135°–145° was first analyzed (I). This was redistilled several times and the product boiling at 135°–140° was analyzed (II).

I. Substance, weight, - - - - - 0·4740 gr.
$\text{Si}\Theta_2$, - - - - - - - 0·1285 "

II. Substance, weight, - - - - - 0·4360 "
$\text{Si}\Theta_2$, - - - - - - - 0·1185 "

	I.	II.	Theory.
Si,	12·64	12·68	12·61 per cent.

Action of Boric Acid on the Silicate of Ethyl.—In the hope of obtaining an ether containing boric acid and silicic acid together, we heated 3 grams of boric acid, which had been previously melted, with 28 grams of silicate of ethyl (2 molecules of boric acid for 3 of silicate of ethyl) during 12 hours at 240°.

The whole of the acid dissolved, and on opening the tube there was no evolution of gas. After six or eight fractionated distillations, products were obtained with a very high boiling point, and a considerable quantity of a liquid with a lower boiling point; of this latter there distilled:

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Below 119°	2 gr.
119°–125°	8 "
125°–140°	5 "
	12 "

All these portions below 140° burnt with a green flame and did not contain a notable quantity of silica. They consisted in Ebelmen's boric ether in a state of almost complete purity. The true boiling point of this ether is 119°.

The portion 119°–125° was analyzed.

Substance, weight,	0·2105 gr.
CO_2,	0·3795 "
H_2O,	0·1990 "

		Theory. $Bo(C_2H_5)_3O_3$.
C,	49·19	49·31
H,	10·51	10·27

Supposing all the boric acid to have been converted into boric ether, 12 grams of the latter ought to have been produced. The reaction therefore had resulted, not in the production of a mixed ether containing both the acids, but in the replacement of silicic acid by boric. The products boiling higher than 140° consisted in ethers, containing a large amount of silicic acid, and a residue of silica was left in the flask after the distillation. Boric acid acts on silicic ether in the same manner as water, and not like anhydrous acetic acid. It is possible that this reaction may serve as a means of preparing some of the ethers of other acids that have not yet been obtained.

From all the facts observed in this research, the tetratomic character of silicium appears to us proved in the most convincing manner. It is impossible to find simpler formulæ to represent the composition of the monochlorhydrines and trichlorhydrines of ethylic and methylic silicic ethers, or of the monoamylic-triethylic, monoethylic-trimethylic and monoethylic-triethylic ethers, or of the acetine; and only by returning to the old atomic weight of oxygen, can the hexethylic and hexamethylic-disilicic ethers be written with a simpler formula, since they contain O_7.

The existence of these compounds and their formulæ is interpreted most readily by supposing, as we have done, that the chlorid of silicium, $SiCl_4$, silicic acid, SiO_2, and the silicic hydrate SiH_4O_4 act in the same way as the polybasic acids known in mineral and organic chemistry.

In another paper we intend to publish the results, that we have obtained in studying the compounds of silicium with the alcoholic radicals.

Boston, Dec. 5th, 1866.

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ART. XXXVIII.—*On the supposed falsification of samples of California Petroleum;* by S. F. PECKHAM, late Chemist to the California Petroleum Company.

HAVING been almost exclusively engaged during the last eighteen months in both technical and scientific analyses of California bitumens, my attention has been repeatedly called to the small amount of light oils suitable for illumination yielded by these substances, when treated by the ordinary process of fractional distillation. This low percentage of light oil, and consequent inferior commercial value of the crude materials, early led me to compare my own results with those of other experimenters and analysts of California products.

The first reports that I obtained, were published in the prospectus of the Philadelphia and California Petroleum Company. These embraced the details of an examination made by Mr. Peter Collier, under the direction of Prof. Silliman; those of C. M. Warren, Esq., of Brookline, Mass., and those of Prof. J. M. Maisch of Philadelphia. I afterwards received a pamphlet containing an article published in this Journal, vol. xxxix, May, 1865. This article contained the results of the analysis made by Mr. Collier and the report of Mr. Warren, before mentioned. The report of Mr. Maisch was dated March 18th, 1865; that of Mr. Warren, March 31st, 1865; that of Prof. Silliman was without date.

The material operated upon by Prof. S. was said to have come from a spring upon the Simi ranch in Santa Barbara county; and that treated by Messrs. Warren and Maisch was said to be a portion of the same sample. Without concurrent testimony, the similarity of the results obtained by those gentlemen, even by different methods of operation, sufficiently proves the identity of the crude material.

My own results, which I propose to compare with those above mentioned, were obtained by the treatment of petroleums gathered from the natural outcrops known as the Cañada Laga and Pico springs, and two samples, of different density, from the estate of the Hayward Petroleum Co. The Stanford oil springs adjoining and resembling those of the H. P. Co., and a tunnel in the San Fernando mining district, the product of which is a little more dense but otherwise resembles that of the Pico spring, were the only other localities in Southern California, yielding petroleum in any other than the most insignificant quantities, at the time I left that region in June last.

I am perfectly familiar with each of these localities and their products. All the samples treated by me, with but one exception—the lightest sample from the H. P. Co.—were gathered

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under my own eye, most of them with my own hand. The exceptional sample was gathered and furnished me under the personal supervision of William H. Stone, Esq., at that time Superintendent of the California Petroleum Company.

My experiments were first confined to the petroleums of the Cañada Laga spring, and the tunnels of the H. P. Co. The great dissimilarity between my results and those detailed in the published reports, led me to inquire of persons familiar with the country, concerning the spring upon the Simi ranch, with the intention of procuring some of the oil for analysis. I was then and subsequently informed that no "green oil" (petroleum) springs existed upon that estate. I then sought the officers of the Philadelphia and California Petroleum Company resident upon their estate, and was informed by them that no oil of sp. gr. corresponding to that given in the reports (average ·8635 = 33·5° Baumé) was to be found upon their property, nor so far as they could learn in that part of the country. I was informed that the lightest oil yielded by any natural outcrop in that section, was that of the Pico spring, situated very near but without the boundary line of the San Francisco ranch. The sp. gr. of this oil, as estimated by myself, is ·8832=28·5° Baumé. I was assured by Mr. Lyon who had had charge of the spring for more than a year prior to June 1st, 1866, that no oil lighter than sp. gr. 28·5° Baumé had ever been obtained from it. I have reason to believe, that before I left Southern California, I visited more of the bituminous outcrops of Santa Barbara and Los Angeles counties, than had ever before been visited by any single person who had written upon this subject; and I was unable to discover any trace of the existence of a natural outflow, yielding lighter material than the Pico Spring.

The specimen of oil from the Pico spring examined by me, was dipped from the pool by Mr. Lyon, under my own eye, May 7th, 1866. The months of May and June are the most favorable season that occurs in that climate, for gathering specimens of the liquid varieties of bitumen. This arises from the fact, that the rains of the winter and spring months, have so swollen the springs, that water which almost invariably accompanies the bitumen comes to the surface, in much greater quantity, and much more rapidly than at any other season; consequently the oil reaches the surface quicker, is less oxydized and thickened, and of less density.

These facts prove, that no petroleum exists upon the Simi ranch, and that no oil had been discovered in Southern California from any natural outcrop, prior to June 1st, 1866, of lower sp. gr. than ·8832=28·5° B.

But one conclusion can be deduced from these premises, viz: the oil examined by Messrs. Silliman, Warren and Maisch, must

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have been falsified by admixture of lighter oil, or the oil must have experienced an "organic change" during transmission from San Francisco to New York. The latter supposition is simply ridiculous, even if its incorrectness were not established by proof. I last summer brought a sample from San Francisco to New York, from both the Cañada Laga and Pico springs. Neither of them experienced the slightest change in density.

Having become convinced of the probable falsification of the samples analyzed by the above named gentlemen I was led to more closely compare their results with my own. A study of the details of their analyses elicited the following as the characteristics of this sample of petroleum.

Color, "dark brown." (S.)*
Consistence, "thin and mobile as water." (S.)
Odor "not offensive," (S.) resembling refined Pennsylvania petroleum.
Density, ·861, (S), ·863 (M.), ·864 (W.), average ·863=33·5° B.
Distillation,
"Condensable vapor appeared at 60° C." (S.)
"Boiled at 123° C." (S.)
" Yielded below the boiling point of mercury, 50–60 pr. ct." (S.)
" do. above do. 35–45." (S. and W.)
Sp. gr. of 1st 10 per cent of distillate, ·755. (S.)

		S.	W.	M.
Reserved as naphtha,				
	per cent,	20	6	7·8
	sp. gr.	·765	·753	·756
Reserved as burning oil,				
	per cent,	50	42	50
	sp. gr.	·837	·805	·8219
Reserved as lubricating oil,				
	per cent,	26	25	42·2
	sp. gr.	·896	·910	Residue less in retort.
Loss,	per cent,	4	7	0

The portion reserved as naphtha is of the same sp. gr. at which refiners of Pennsylvania petroleum usually commence to run off burning oil. (M.) If this oil were fractionated the same as is customary in treating Pennsylvania oils, it would furnish, according to—

Silliman.	Warren.	Maisch.
60 per cent.	52 per cent.	57·8 per cent.
Sp. gr. ·815=42° B.	·805=44° B.	·920=41° B.

or about 55 per cent of sp. gr., ·810=43° Baumé.

The burning oil before treatment has very little odor, and that not at all disagreeable. (S., W., M.) Crude oil yields very readily to treatment with sulphuric acid and soda lye, furnishing a refined oil of light color and agreeable odor (S., W., M.), the illuminating qualities of which are not excelled by any.

* Quotations marked "S." are from the report of Prof. Silliman; those marked "W." are from that of Mr. Warren; those marked "M." are from that of Mr. Maisch.

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The lubricating oils are of very low specific gravity; of a reddish color in the crude state, and easily rectified. (S.)

The crude oil yields a very large percentage of distillate. The lightest oils are not very light (W., M.), and the odor of the crude distilled oils not more disagreeable than that of many samples of so-called commercial refined oil. (S.)

I recently obtained from the office of the Philadelphia and California Petroleum Company, a small portion of a sample of oil said to have come from the Pico Spring. This was supposed to be a portion of the sample examined by Messrs. Silliman, Warren and Maisch. I also obtained from the same place a small bottle of oil, labelled "crude oil," and bearing upon the seal the initials "B. S." This bottle of oil accompanied specimens of illuminating and lubricating oils received from Prof. Silliman. These two oils were identical in specific gravity and other physical properties. The sp. gr. of these samples is ·868, a difference of only ·005 from that examined by those gentlemen; a difference which may be accounted for, as the result of oxydation during two years.

From an examination of 200 cc. of this oil, I note the following additional characteristics.

With the thermometer bulb immersed in the boiling oil, the oil boiled at 124° C., and with Mr. Warren's condensing apparatus, yielded with the boiling oil at 200° C., ·174; at 220° C., ·250; at 227° C., ·276; with the bath at 200° C., 200 cc. yielded 77·5 cc., or 38·75 per cent of colorless distillate. The sp. gr. of this distillate is ·785=50° Baumé.

From my own examinations of California oils of undoubted authenticity, I gather the following characteristics.

Color.—The color of genuine oils is dark green, when fresh, with marked dichroism. Three samples which I gathered in May and June of last year, when opened in Boston about ten weeks afterwards, appeared of a dark brownish black, having nearly lost their dichroism.

Consistence.—I have seen no oils from natural outcrops that could properly be called "thin and mobile." They are of about the consistence of olive or linseed oil. The oils from tunnels when fresh, are lighter colored, and more mobile fluids.

Odor.—The odor of Southern California petroleums is peculiar; not as offensive as those of Pennsylvania and Canada; but at the same time unlike refined kerosene.

Density.—The density of the oil from the

Cañada Laga spring is, - - -	·9184=23° B.
Tunnel in "Brea. Cañon," H. P. Co., -	·9023=25° B.
Pico spring, - - - - -	·8832=28·5° B.
Lightest oil examined by myself from H. P. Co.,	·875=30° B.
Lightest oil said to have been procured from the extremity of a tunnel 95 ft. in length, H. P. Co.,	·8525=34·5 B.

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Petroleum springs existed upon the property of the H. P. Co., prior to the commencement of their operations. I have been told that the oil yielded by them was very dense; lower than 25° Baumé. Upon the property known as the Stanford Oil Springs, tunnels are said to have yielded oil of sp. gr. 31° Baumé, and a tunnel upon the property of the Wylie Springs Oil Co., yielded in June last, oil of sp. gr. 23° Baumé. All of these tunnels have been run since July, 1865.

Distillation.—No condensable vapor appeared from any sample at 100° C.

Pico spring boiled at - - - - - - -	174° C.
Cañada Laga, - - - - - - - -	182° "
H. P. Co., heavy, - - - - - - - -	182° "
Pico spring yielded below the boiling point of mercury,	26·5 per ct.
Total amount of distillate from the Cañada Laga, -	93·75 "

Sp. gr. of first 10 per cent of distillate,

	Cañada Laga, - - - - - -	·852
	Pico spring, - - - - - -	·805
Tunnels,	H. P. Co., heavy, - - - - -	·785
	H. P. Co., light, - - - - -	·766

None was reserved as naphtha.

Reserved as burning oil sp. gr. ·810=43° Baumé, by ordinary fractional distillation—

Cañada Laga, - - - - - - -	3·5	per cent.
Pico spring, - - - - - - -	13·5	"
H. P. Co., heavy, - - - - - -	28·5	"
H. P. Co., light, - - - - - -	35·9	"

The absence of either very light, or very dense oils, is a marked peculiarity of the distillate of Southern California petroleums, when they are treated by direct heat in the ordinary process of fractional distillation. The lubricating oils range in sp. gr. from 25°–29° Baumé.

The odor of the crude distillate is pungent, resembling that of the crude distillate of Pennsylvania petroleum. It yields readily to treatment, and furnishes a refined oil of great transparency, very free from color and of agreeable odor. I have never seen any refined California petroleum of illuminating power equal to the best refined Pennsylvania oil.

The lubricating oils are of very low sp. gr., of a reddish color, and easily rectified.

Mr. Warren's condensing apparatus, with the bath at 200° C., gave from the

Cañada Laga,	18·5	pr. ct., sp. gr. - - -	·810
Pico springs,	18.416	" " - - -	·800
H. P. Co.,	26·08	" " - - -	·800

A comparison of the characteristics of the sample of petrole-

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um examined by Messrs. Silliman, Warren and Maisch, with those of the samples of Southern California petroleum, examined by myself, exhibits the following very marked and important differences.

Consistence differing, as water and olive oil.

The odor of one is strikingly similar to that of refined Pennsylvania petroleum; that of the others without resemblance thereto, and peculiar though not offensive.

The density of the one is ·020=5° Baumé, lighter than any oil that could possibly have been procured in that region prior to July, 1865.

The boiling point of the one is 50° C. below, and the sp. gr. of 1st 10 per cent of distillate from the same is ·050 below that of the other.

The absence of light oils, that could be classed as naphtha.

The per-centage yield of burning oil of the same grade is 41·5 per cent more in the one than in the other. The odor of the crude distillate of the one is agreeable, that of the other pungent. The illuminating oils of the one are of superior quality, those of the other are not above the average.

One yields of light oils, not condensed at a temperature of 200° C., 38·75 per cent, of sp. gr., ·785; the others yield only from 11·5 to 18·416 per cent, of a sp. gr. from ·800 to ·810.

These differences all point to the falsification of the oil examined by those gentlemen, by admixture of light oil. It is further proved by the fact, that the lightest oils obtained from the sample furnished them are identical in sp. gr. with the lightest contained in refined Pennsylvania petroleum; by the ease with which the burning oils are rectified, and by their superior illuminating qualities. Finally, their partial California origin is proved by the low sp. gr. of the lubricating oils; by their peculiar red color, and the absence of paraffine.

The following remarkable coincidences seem to indicate that the falsification consisted in the addition of an equal portion of refined Pennsylvania oil of sp. gr. 43° Baumé =·810, to crude oil from the Cañada Laga spring. I tested four different samples of illuminating oil purchased in San Buena Ventura by the Cal. Pet. Co. The sp. gr. of each of them was ·810; and I was told that the larger portion of the illuminating oil sold on the Pacific coast, is of that density. The sp. gr. of the Cañada Laga oil is ·918, which added to ·810 and the sum divided by two, equals ·864 as the average density; ·864 is the sp. gr. of the oil examined by Mr. Warren.

I obtained by ordinary distillation from the Cañada Laga oil 3·5 per cent of distillate, of sp. gr. 43° B.=·810. The results obtained by Mr. Warren were equivalent to about 55 per cent of the same grade. This slight increase is a natural result of

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the distillation of a mixture of light and heavy oils, and is also due to the superiority of the results given by Mr. Warren's process over those obtained by ordinary fractional distillation.

Prof. Silliman notices the fact that when 485 cc. were distilled from 1000 cc., the mercury suddenly arose from 320° to 370° C. This remarkable phenomenon clearly indicates that when nearly 500 cc. or 50 per cent had passed into vapor, 485 cc. of which had passed into the receiver, the more dense oils remaining in the retort required a higher degree of heat for their distillation. This phenomenon would no doubt be observed, during the distillation of a mixture of equal parts of refined Pennsylvania petroleum, and a dense oil like that of the Cañada Laga, yielding a distillate, 90 per cent of which distills at a temperature at or above the boiling point of mercury.

It will also be observed, that by Warren's process the Cañada Laga oil yields 11·5 per cent of sp. gr. ·810 or 43° B, and that by the same process the oil examined by him yielded about 55 per cent of the same grade, or 50 per cent plus 5 per cent. I obtained by the ordinary process 93·75 per cent of distillate, a very large amount, the loss being 6·25 per cent. Prof. Silliman obtained 96 per cent, or 50 per cent plus 46 per cent, the loss being 4 per cent, or a little more than half that which I experienced. However these are mere coincidences, striking though they may be.

The foregoing details have been gathered from the results of a large number of experiments, made both in California and in the Eastern states, for the purpose of ascertaining the commercial value of California bitumens. They are offered for the purpose of correcting, what I am confident is an error, and to assist in the dissemination of reliable information respecting California Petroleums.

Providence, R. I., March 6th, 1867.

ART. XXXIX.—*Contributions from the Sheffield Laboratory of Yale College.*—XIV. *On Kaolinite and Pholerite;* by S. W. JOHNSON and JOHN M. BLAKE.

THE study of certain minerals termed pholerite, nacrite, steinmark, and kaolin, leads to the conclusion that a number of substances which are included under these various designations must be classed together and constituted into a mineral species in virtue of possessing chemical and physical properties which admit of precise definition. This species must have a new or unappropriated name, and we propose for it that of Kaolinite, in allusion to the material which furnishes it most commonly and abundantly.

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The chemical composition of this mineral was first deduced by Forchhammer from the analysis of a number of kaolins. It is represented by the formula $4\bar{S}i\,3\bar{A}l\,6\dot{H}$, or by $2\dot{S}i\,\bar{A}l\,2\dot{H}$. The *per cent* proportions vary considerably according to the atomic weights employed in the calculation. In the table that follows, p. 358, are given the percentages reckoned on the atomic weights adopted by Gmelin (Handbook, English ed.), by Rammelsberg (Handbuch d. Mineralchemie), and by Fresenius (Quantitative Analysis, 4th ed.).

Of the substances which have come under our notice, having the above composition, the most striking is the so-called nacrite, from the Einigkeit mine at Brand, near Freiberg, Saxony. It is described by Breithaupt (Berg. u. Hüt. Zeit., No. 40, 1865) as occurring "in snow-white or yellowish six-sided tabular crystals in fan-shaped or reniform aggregates, and having pearly luster passing into adamantine. Sp. gr. 2·63." The analysis of this mineral made by Richard Müller appeared in Dana's 9th Supplement, and is quoted below.

DesCloizeaux, in the Supplement to his Manuel de Minéralogie, p. 549, remarks concerning this mineral as follows: "There has been recently discovered in Saxony a pholerite, at first called *nacrite*, which occurs in large macled hexagonal plates. These plates are composed of six triangular sectors, whose boundaries, though quite vague, nevertheless give indications of composition parallel to the faces of a right rhombic prism approximating the angles 120° and 60°. They cleave easily in the direction of the base of this prism; their interior structure is fibrous, and their surfaces are slightly undulated. Notwithstanding the plates are transparent when sufficiently thin, their action on a polarized beam of parallel rays is very irregular. In convergent light there are seen in each sector the hyperbolas which indicate two diverging optical axes whose plane is normal to the side situated upon the hexagonal contour and is consequently parallel to the principal diagonal of the base of the fundamental prism. The bisectrix is negative and evidently normal to the plane of cleavage. The dispersion of the axes is feeble: at 45° from the plane of polarization it is shown by the symmetrical distribution of the colors about the two hyperbolas, and the separation of the axes is greater for the red rays than for the violet," &c.

Our observations, made on a specimen in the cabinet of Professor Brush, are as follows. The crystals occur in hemispherical groups of about 4 mm. in diameter. These groups have a radiated structure, as is evident from their cleaving into quite thin wedge-shaped laminæ. The laminæ themselves appear to have a radiate structure at right angles to that indicated by the cleavage, for, when viewed by polarized light, dark shades of color branch out irregularly from near the center of the thin

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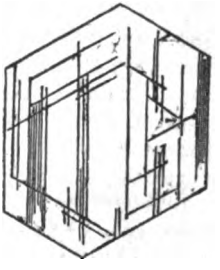
edge of the wedge, and these rotate with considerable uniformity as the plane of polarization is changed. When magnified, the surfaces of the laminæ are seen to be striated in three directions. These striæ intersect at angles of 60° and 120°. The microscopic structure under polarized light gives evidence that the ultimate plates of these groups are twin or compound crystals. In a section ground thin, parallel to the cleavage direction, crystals were seen superposed, the outline of one corresponding to the striæ of another, while, optically, they did not correspond. The portions of crystals thus distinguished by polarized light, were often elongated three or four diameters, and this elongation had the same relation to the plane of polarization as observed in the mineral from Summit Hill to be described presently. Sections of the groups often give an approximately hexagonal outline. The plates of this mineral are flexible, non-elastic, and have a soft, soapy feel.

The white pearly luster of the "nacrite" appears to be due to strata of air included between the separate crystalline plates composing a mass. It, as well as the crystals presently to be noticed from Summit Hill, exhibits the colors of pearl. This can be seen under the microscope by reflected light. If perpendicular illumination be not used, an oblique position of a plate on the slide is most favorable to reflect the light into the instrument and bring out the color. This iridescence may be due either to the fine striæ upon the crystal or to the colors of thin plates of cleavage. As a comparative test, quite thin blown glass, when crushed into a mass, was found to give the pearly luster perfectly, without at the same time exhibiting color; while the thinnest glass in the same condition showed both in a high degree.

A second substance in possession of Prof. Brush was received from Prof. W. T. Rœpper, of Bethlehem, Pa., and was found in a cavity in a coal seam at Summit Hill, Carbon Co., Pa. It bore the label Pholerite. It is a brown scaly powder, which on digestion in hydrochloric acid gives up oxyd of iron to that solvent and becomes nearly white. It has a pearly luster and soapy feel. Magnified fifty diameters, the substance appears made up, for the most part, of well defined crystalline plates. The average size of the plates is ·003 of an inch, the largest are ·005 of an inch in breadth; they are in general extremely thin. They have, as nearly as the mode of measurement employed would show, the angles of perfect hexagons, 120° (see figure). The method used was to draw them upon paper under the camera lucida,



Kaolinite.—Scale 300 diams.

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with the aid of a straight edge, to a scale of 650 diameters, and to measure the angles of the drawings with the hand goniometer. Many of these tables are elongated in a direction parallel to one of the sides of the hexagon, sometimes to two diameters. They are striated, and the principal striæ concur with this elongation.

Besides these extremely thin and isolated hexagonal plates, the substance contains prismatic aggregates of similar plates. These aggregates have all degrees of thickness, amounting in some instances to ·003 of an inch. Some of them are obviously homogeneous crystals, composed of closely parallel laminæ perfectly resembling in their aspect prisms of mica. When viewed laterally they are often quite transparent and have deep transverse striæ, which indicate perfect basal cleavage. In other cases the structure of these prisms is less compact and symmetrical; the plates being loosely combined and somewhat separated from each other on one side of the prism.

The longer tables, when seen in polarized light, cease to show a difference of shade on the field, or of tint with the use of selenite, when the plane of polarization of the analyzer is parallel with or at right angles to the axis of elongation. The same occurred with crystals on edge, when the plane of polarization was perpendicular or parallel to the cleavage plane.

The thicker plates, when not in the positions just mentioned, have very evident effect on the polarized beam. This indicates a considerable separation of the optical axes. Like the laminæ of "nacrite," the crystals of this substance exhibit, when properly illuminated, the colors of pearl. When ignited, the substance is seen to increase in bulk, and the microscope shows this to be the result of the exfoliation of the crystals due to the expulsion of their water of combination. This mineral differs from the so-called "nacrite" in not being macled. Some fragments from the exterior of the groups of nacrite crystals resemble this "pholerite" closely, showing evident hexagonal outlines and striæ with the angles 120° and 60°. We found the specific gravity of the purified mineral to be 2·59. An analysis made on 442 milligrams by fusion with carbonate of soda gave the following results:

Silica, - - - - -	45·93
Alumina, and trace of oxyd of iron, -	39·81
Water, - - - - -	14·02
	99·76

The substance described as pholerite by Dr. F. A. Genth (this Jour., [2], xxviii, 251) is of similar character and occurrence. It was found in coal mines at Tamaqua, Pa., in scales of a yellowish white color, which became white on treatment with dilute hydrochloric acid, and at Pottsville, Pa., in snow-white scales of

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a pearly luster. Dr. Genth remarks that under the microscope the scales appear to be clinorhombic. His analysis of this substance, after purification by hydrochloric acid, is given below.

The first mention of a crystalline substance with the composition of Forchhammer's kaolin that we have been able to find is by Wöhler, who describes, under the name steinmark, a pale yellow coherent mass which is converted by dilute hydrochloric acid, with solution of a little oxyd of iron, into a white shining powder. (Ann. d. Ch. u. Ph., lxxx, 122.) With help of a lens, Wöhler found it to consist of "shining laminæ, which, when magnified 200 diameters, were seen to be transparent and to consist in part of rhomboidal tables. Before treatment with dilute hydrochloric acid the mass had an earthy fracture which assumed luster by rubbing, an unctuous feel, and adhered strongly to the tongue. Sp. gr. 2·6." The locality was Schneckenstein, Saxony. The analysis by Prof. W. S. Clark, now of Amherst College, is given below.

In response to our application, Prof. Clark has kindly favored us with a fragment of this substance. We observed that it requires to be acted on with hot concentrated hydrochloric acid for some time before falling to a white powder. Microscopic examination of the substance thus purified confirmed our anticipation of its close physical resemblance to the minerals already noticed. It consists of plates and bundles of plates, the largest being ·001 of an inch or less in breadth, and when sufficiently magnified has a great similarity to the kaolinite from Summit Hill. The angles of the plates, as well as of the striæ which they exhibit, approximate 120°. Under a high power the striæ are seen to be formed by the edges of superposed and conformable plates; some loosely aggregated bundles resembled those to be noticed presently, as occurring in the kaolinite from near Richmond, Va. [See note on a subsequent page.]

In 1859, Knop analyzed a mineral of the same composition from Zeisigwald near Chemnitz, consisting of microscopic sharp rhombic plates. (Jahresbericht der Chem., 1859, p. 789.)

Stolba has also published an analysis (see below) of a substance occurring in the coal mines of Schlan, Bohemia, in the form of brilliant white scales, which is obviously kaolinite. (Jour. für prakt. Ch., xciv, 116.)

In his Manuel de Minéralogie, DesCloizeaux, in describing pholerite, remarks, p. 190: "a variety from Lodève, in somewhat contorted scales, exhibits under the polarizing microscope, indications of two quite divergent systems of axes, of which the negative bisectrix is almost normal to the plane of the laminæ; the interior structure otherwise appears highly irregular." This "variety" is the mineral analyzed by Pisani from the same locality (Comptes Rendus, liii, 1072, also Dana's 10th Supplement),

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and the words of DesCloizeaux, above quoted, appear to be the first recorded optical observations on kaolinite. Pisani's analysis is given in the subjoined table.

Kaolin is described by nearly all writers as an opake amorphous substance. Some have mentioned it to contain minute transparent plates, but have supposed them to be sheets of mica or other admixture. We have examined microscopically twenty specimens of kaolin, pipe- and fire-clay. Most of these are of unknown origin. In them all is found a greater or less proportion of transparent plates, and in the most of them these plates are abundant, evidently constituting the bulk of the substance. The kaolin from Diendorf (Bodenmais), Bavaria, is perhaps the most finely divided of all the white clays we have studied. When dusted dry upon a glass slide it appears to consist chiefly of masses of a white substance that are opake or nearly so in transmitted light, but, when fully illuminated above and below, have the translucent aspect of snow in the lump. Interspersed among these masses may be seen extremely minute transparent plates of irregular rounded outline. When brought into water the masses are almost entirely resolved into similar transparent plates, most of which are not more than ·0001 of an inch in breadth. This description applies to all the finer plastic clays. Even the dark-colored Stourbridge clay is made up in large part of transparent laminæ, as is a compact sedimentary brownish-gray pipe-clay from Table mountain, Tuolumne Co., Cal. The same is true of the blue fire-clay from Mt. Savage, Md., the white clays of Brandon, Vt., Perth Amboy, N. J., Reading, Pa., Chester Co., Pa., Long Island, and various other white and colored clays from unknown localities. On several specimens of kaolin, especially on one collected at one of the hematite mines at Beekmann, N. Y., we have observed pearly glistening surfaces on the interior of cavities. Viewed in reflected light, by the microscope, these surfaces were seen to be covered with minute scaly crystals, or crystalline aggregates, which, however, revealed no regular outlines.

A white, pulverulent substance, having much the appearance of powdered starch or wheat flour, found near Richmond, Va., was recently analyzed by Mr. Burton in the Sheffield Laboratory. Its composition agrees with Forchhammer's formula (see below), and under the microscope it is seen to be made up for the most part of transparent plates ·001 of an inch or less in breadth, and of prismoidal bundles, obviously composed of loosely aggregated plates, similar to those found in the kaolinite from Summit Hill. These bundles are usually curved, and their length is often several times greater than their breadth. The bundles are fan-shaped in some instances, and the plates are rarely parallel to each other. The edges of these bundles are frequently presented

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and in this position they have the greatest effect upon polarized light. They have least influence on the polarized beam when the plane of polarization is perpendicular or parallel to the plates in this position. The separate plates are of broken and irregular outline. Grains of quartz are intermingled.

In four other specimens of kaolin from unknown (probably European) localities, similar prismatic bundles were observed. The bundles were usually curved and irregular; in some instances their length was four or five times their breadth. One of these four kaolins contained hexagonal plates that could be made out with ease under a one-fourth inch objective. Two others, when rubbed between the fingers, assumed a distinct pearly luster; and after this treatment, by which the prismatic crystals were broken up, microscopic examination revealed abundance of hexagonal plates.

Prof. Brush has called our attention to a specimen of fluor from Zinnwald on which occurs a white powdery substance that passes for kaolin. It consists entirely of perfectly definite hexagonal tables averaging ·0005 of an inch in diameter, which are usually thin but sometimes are aggregated into short prisms.

The kaolin, pseudomorphous after prosopite, from Altenberg, Saxony, the analysis of which by Richter (Pogg., xc, 315) is given below, though compact in texture, is found by microscopic examination to be made up also of hexagonal plates and bundles of plates.

The plasticity of clay is a physical character, and appears to have a close connection with the fineness of the particles. The kaolinite of Summit Hill, consisting chiefly of crystal-plates averaging ·003 of an inch in diameter, is destitute of this quality. The nearly pure kaolinite from Richmond, Va., occurring mostly in bundles of much smaller dimensions, the largest being but ·001 of an inch in diameter, is scarcely plastic. The four kaolins of unknown origin which we have described as also consisting largely of prismoid crystals are scarcely plastic, though when rubbed between the fingers they become more soapy to the feel. So too the crystallized kaolinite accompanying fluor from Zinnwald is a scarcely coherent unplastic substance.

The more finely divided fire-clay from Long Island, is more "fat," while the Bodenmais porcelain earth and other clays, in which the bundles are absent and the plates are extremely small, are highly plastic. So, too, the Summit Hill crystals, when triturated in an agate mortar, yield a powder which, when breathed upon, acquires the argillaceous odor, under the microscope perfectly resembles the finer kaolins, and in the wet state is highly plastic and sticky.

Sommaruga has published analyses of two Passau kaolins,

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employed in the imperial porcelain manufacture at Vienna, one of which is "fat" and the other "short." The composition of the two is almost identical (see Chem. Centralblatt, 1865, p. 268), and the different degree of plasticity is thus evidently connected with their state of division.

It is possible also that the plasticity of a clay is related to the form of the plates of kaolinite, perhaps to their thickness, but this is a subject that requires further investigation. Our observations indicate that the impurer sedimentary clays are the most plastic. Some of these are perhaps not so fine as "shorter" kaolins. The plasticity may be, therefore, in part due to the impurities.

In the subjoined table are given the analyses of various crystallized kaolinites which have been previously referred to.

Analyses of crystallized Kaolinite.

	$\dddot{Si}$	$\dddot{\bar{Al}}$	$\dot{\bar{H}}$	Other ingredients.
Kaolinite (Nacrite), Freiberg, Saxony, R. Müller,	47·74	39·48	14·07	....
" (Pholerite), Summit Hill, Pa., S. W. Johnson,	45·93	39·81	14·02	....
" ("), Tamaqua, Pa., F. A. Genth,	46·98	39·65	13·69	0·17
" (Kaolin), Richmond, Va., B. S. Burton,	48·56*	35·61	12·88	2·95
" (Steinmark), Schneckenstein, Saxony, W. S. Clark,	46·76	35·59	13·42	0·94
" (Kaolin), Zeisigwald, Sax., A. Knop,	49·91	35·23	14·86†	....
" ("), Altenberg, " R. Richter,	45·63	39·89	13·70	0·60
" (Pholerite), Lodève, France, Pisani,	47·00	39·40	14·40	....
" ("), Schlan, Bohemia, Stolba,	47·93	36·78	15·29	....
Calculation after Gmelin ($\dddot{Si}$=15, $\dddot{\bar{Al}}$=13·7) requires,	47·19	39·12	13·69	....
" " Rammelsberg ($\dddot{Si}$=14·8, $\dddot{\bar{Al}}$=13·68) requires,	47·05	39·21	13·74	....
" " Fresenius (Dumas) ($\dddot{Si}$=14, $\dddot{\bar{Al}}$=13·75) requires,	46·33	39·76	13·90	....

We find more than thirty analyses of clays, kaolins, and steinmarks, which obviously agree with the formula above given. Some of these analyses appear to have been made on the kaolin as it occurs in nature; others, however, were made on the washed kaolin as prepared for the porcelain manufacture; and in still other cases, as in Forchhammer's investigations, the clay was first exhausted with hydrochloric acid and the analysis was performed on the residue, allowance being made for quartz and substances insoluble in sulphuric acid.

It is obvious then that the basis of many kaolins and clays is a soft, white, transparent, infusible mineral, which crystallizes in forms probably belonging to the trimetric system, has a density of 2·6, when crystallized has usually a pearly luster, is insoluble in dilute hydrochloric acid, and in most of its forms is difficultly decomposed by hot concentrated hydrochloric acid, but is resolvable by hot oil of vitriol and dissolves completely in strong solutions of caustic alkalies. In chemical composition

* Including some quartz. † By difference.

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it agrees with the formula deduced by Forchhammer from his analyses of porcelain clays, viz., $3\bar{\text{Al}}\,4\bar{\text{Si}}\,6\dot{\text{H}}$.

This substance is not the nacrite of Vauquelin or Thomson, which contained at the most but one per cent of water. It is not the pholerite of Guillemin, as we shall presently see. The old terms kaolin, steinmark and lithomarge have been so loosely applied that they do not define it.

The massive yellow steinmark from Rochlitz has the composition of kaolinite, but with a portion of the alumina replaced by sesquioxyd of iron. Klaproth's analysis (Chemische Abhandlungen, vi, 287) is as follows:

Silica, - - -	45·25
Alumina, - - -	36·50
Sesquioxyd of iron, - -	2·75
Water, - - -	14·00
Potash, - - -	*trace.*
	98·50

Digested in hot concentrated hydrochloric acid it is scarcely acted upon, but retains its yellow color without falling to powder, as we have observed with a specimen in Professor Brush's cabinet.

The steinmark from Buchberg, analyzed by Zellner, that from Rumpelsberg examined by Rammelsberg (Ramm. Handbuch, p. 576), that from Saszka analyzed by v. Hauer (Jahresbericht der Chem., 1856, 860), and the *severite* of the latter (Ramm., Handbuch, p. 1012), are evidently impure indurated kaolinite.*

Brongniart and Malaguti have investigated a large number of kaolins, and some of the results of their analyses have led to the adoption of the formula $\bar{\text{Al}}\,\bar{\text{Si}}\,2\dot{\text{H}}$ (or $2\bar{\text{Al}}\,3\bar{\text{Si}}\,4\dot{\text{H}}$). But of the 31 analyses by B. and M. but four agree to the above formulæ within 1 per cent of silica, but six within 2 per cent, and but nine within 3 per cent. (See Dana's Min., 4th ed., vol. ii, pp. 249–50.)

Furthermore, the data from which this formula has been proposed, were not derived from the original analyses of the clay, but from these analyses "corrected" by deducting from the total silica (exclusive of quartz), the loss suffered by boiling the kao-

* Halloysite cannot be confounded with kaolinite although it is another hydrate of the same silicate of alumina that exists in the latter. Its formula is $4\bar{\text{Si}}\,3\bar{\text{Al}}\,12\dot{\text{H}}$, or $2\bar{\text{Si}}\,\bar{\text{Al}}\,4\dot{\text{H}}$. The specimens of this mineral from Guatequé analyzed by Boussingault, and those from Houscha and Anglar examined by Berthier, lost one-half their water (8–9 per cent) on drying at 212°, and thus acquired the formula of kaolinite. It cannot be assumed that this loss was due to hygroscopic water, for many substances when dried at 212°, or below that temperature, lose a part or all their crystal water. Thus selenite loses *about* three-fourths of its water at 212°. The quantity is not, however, definite. Halloysite is of much inferior density (sp. gr.=1) to kaolinite, is more easily decomposable by acids, and is without doubt a fairly characterised species.

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lin for one and a half minutes with a five per cent solution of caustic potash, this loss being assumed to be accidental hydrated silica. This mode of correction is obviously of no value. On the one hand, the caustic potash might dissolve the kaolinite itself from the more finely divided specimens. Berthier and Rammelsberg have both observed the solution of kaolin in strong potash ley. On the other hand, treatment for so short a time would scarcely suffice to remove all the free silica from a kaolin that contains a large proportion of that substance, if our analytical experience enable us to judge. Again, the analyses appear to have been intended in the first place for technical purposes, and were made, not on specimens selected with reference to their purity, but on the clays in bulk employed in the porcelain manufacture. It is plain that they are not adapted to throw light on the chemical composition of the basis of kaolin. Least of all do they give evidence of the existence of the compound $\dot{\bar{A}}l\,\dot{\bar{S}}i\,2\dot{H}$ in the generality of clays.

We have been able to find but two analyses of kaolin made by Forchhammer's method that lead to this formula. On the other hand, eighteen of Malaguti's uncorrected analyses agree with Forchhammer's formula, and eight of them as closely as those of the crystallized varieties whose composition is given in our table above. It would be strange if, out of all the kaolins that have been studied some should not be nearly pure, except so far as containing fragments of quartz and other minerals insoluble in sulphuric acid. We find thirty kaolins agreeing with Forchhammer's formula and but two with Malaguti's.

The composition of the base of a material so heterogeneous as kaolin is likely to be, cannot in any case be deduced from analyses made on material not evidently pure, no matter how numerous they may be. But the fact that the composition of a substance whose purity cannot be ascertained by mechanical or optical means, agrees with that of another of like origin and occurrence seen to be homogeneous by the help of the microscope, is demonstration that the first is unmixed with foreign matters.

Pholerite.—That other crystallized hydrous silicates of alumina, infusible, insoluble in hydrochloric but decomposable by sulphuric acid, may exist in clays or may form the basis of clays is not at all improbable. In 1825 Guillemin first described, under the name pholerite, a pure white, pearly substance, occurring in the form of small convex scales, soft and friable to the touch, adherent to the tongue, and giving with water a plastic mass. (Ann. des Mines, xi, 489.)

In 1851 Prof. J. L. Smith published analyses of two minerals, one from Naxos, associated with emerylite, and another from Schemnitz, associated with diaspore, which he considered identical in composition with pholerite. (This Journal, [2], xi, 58.)

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In 1859 Prof. A. Knop published an analysis of a substance found at Niederrabenstein near Chemnitz, the purest forms of which were white bolus-like masses, seen under the microscope to be aggregates of crystalline scales. This claystone (*felsittuff*) Knop referred to pholerite. (Jahrbuch für Min., 1859.)

The steinmark from Georgesstollen, examined by Dumenil, that from Schlackenwald (of radiate structure) analyzed by Rammelsberg, and the Tuesite of Scotland, analyzed by Thomson and by Richardson (Ramm. Handbuch, p. 576), approach Guillemin's mineral in composition, or lie between it and kaolinite.

In the subjoined table is given the composition of these minerals and the percentages required by Guillemin's formula, which is the one that has been deduced from Malaguti's analyses of kaolin, viz., $\dot{\bar{A}}l\,\dddot{S}i\,2\dot{H}$.

	$\dddot{S}i$	$\dot{\bar{A}}l$	$\dot{H}$	Other substances.
Calculated, from Dumas' equivalents, -	39·30	44·98	15·71	
" by Guillemin,* - - -	40·75	43·89	15·36	
Pholerite, Fins, Guillemin, - - -	42·92	42·08	15·00	
" " " - - -	41·65	43·35	15·00	
" Naxos, J. L. Smith, - -	44·41	41·20	13·14	1·31
" Schemnitz, " - - -	42·45	42·81	12·92	
" Chemnitz, A. Knop, - -	39·34	45·90	14·76	
Steinmark, Georgstollen, Dumenil, - -	43·00	40·25	15·50	0·95
" Schlackenwald, Rammelsberg,	43·46	41·48	13·49	1·57
Tuesite, Scotland, Thompson, - - -	44·30	40·40	13·50	1·25
" " Richardson, - -	43·80	40·10	14·21	2·13

The correspondence between the calculation and the analytical results is not strikingly close. It is evident that most of the substances analyzed were not homogeneous, and future investigations must decide the yet open question, whether these pholerites are not really impure kaolinite.

It is to be desired that mineralogists having specimens of these pholerites in their possession, should take measures to decide this point by a study of their physical properties, and by instituting new analyses on material properly purified or shown by the microscope to be homogeneous.

New Haven, Conn., March, 1867.

* This calculation by Guillemin is erroneously given by several writers as a third analysis of pholerite from Rive-de-Gier. Guillemin mentions the occurrence of pholerite at Rive-de-Gier, but made no analysis of the substance from that locality.

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ART. XL.—*Partzite—a new mineral;* by ALBERT ARENTS, Mining Engineer and Metallurgist.

THIS mineral was discovered early in the year 1865 in the Blind Spring mountains, situated in Mono county, California, and first denoted as a silver ore by Dr. A. F. W. Partz, for which reason I applied to it the above name.

It has hitherto never been found in crystals or of a crystalline structure, but always in amorphous masses generally without luster and rarely of a glistening appearance. Its fracture varies from conchoidal to even, and its color from yellowish-green to blackish-green and black—the lighter-colored portions containing the most silver. Oftentimes the mineral has considerable resemblance to the product obtained during the middle of the raking period in cupellation. The amount of silver it contains ranges between 4 and 12 per cent.

In the veins of the Blind Spring district the Partzite occurs in irregular deposits which are often nodular in shape, and occasionally occupy for a distance of many feet the whole width of the veins.

Its sp. gr. is 3·8; its H.=3–4. Before the blowpipe on platinum it is melted, but with difficulty, to a black slag; on charcoal, and especially by adding soda and pulverized charcoal, a metallic button is easily obtained which bears much resemblance to pure antimony. SO_3, ClH, and NO_5 decompose the mineral even in the cold, liberating oxyd of antimony and forming a copper-silver solution.

An analysis of the mineral shows the following composition:

		Relation of oxygen.		Relation of equivalents.		
SbO_3	= 47·65	7·47	7·47	$\frac{7·47}{24}$ = 0·311	=	1
CuO	= 32·11	6·47				
AgO	= 6·12	0·42	=7·54	$\frac{7·54}{8}$ = 0·942	=	3
PbO	= 2·01	0·14				
FeO	= 2·33	0·51				
HO	= 8·29	7·37	=7·37	$\frac{7·37}{8}$ = 0·921	=	3
	98·51					

From the above it will be seen that for 1 eq. of acid there are 3 eq. of bases and 3 eq. of water. We thus obtain the following formula: $(CuO, AgO, PbO, FeO)_3 SbO_3 + 3HO$.

Of arsenic but slight traces were detected which, however, in all probability were due to the presence of fine reticulations of a brilliant green color, by which the mineral is more or less interwoven.

The Partzite occurs together with argentiferous galena, in veins of a magnitude varying from nine inches to eight feet, and has already become the object of extensive mining operations.

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ART. XLI.—*On Contributions to Paleontology, published by the Smithsonian Institution.**

AMONG the recent "Contributions to Knowledge" furnished to the scientific world by the Smithsonian Institution, is the series of publications on systematic Paleontology here enumerated. The importance of these articles demands an extended notice, and the principles followed in their preparation or compilation may be exposed with advantage to students.

Commencing with that which was earliest issued, and which is also the most important, we may congratulate naturalists on the appearance of the first part of Meek and Hayden's "Paleontology of the Upper Missouri." If fullness of detail, joined with conciseness of description and the elimination of characters that are not really pertinent to the group under consideration; if a rigorous comparison of such with related types; and if, finally, a careful revisal of the nomenclature and synonymy of all the groups and species discussed, entitle to a claim of excellence, then is the "Paleontology of the Upper Missouri" preëminently deserving of the fullest meed of praise. It will without question, in such respects, fall behind no work on Paleontology which has yet been published in this country, and is, indeed, the only one in which consistent attention has been paid to details. Mr. Meek, to whom the work is especially indebted for its systematic portion, has long stood among the first of American paleontologists, and these new labors fully sustain his title to this rank.

The part of this work issued carries us through the Silurian and Carboniferous ages, and for the subdivisions, the distribution of Professor Dana has been adopted. The faunas of the several *periods* are successively described, and of such the Potsdam, the Carboniferous and Permian, and the Jurassic are recognized. Subject to such subordination, the species are strictly arranged according to their zoölogical affinities, and under their respective branches, classes, orders, families and genera, and *their* subdivisions when such are recognized. Detailed descriptions are given of the families, subfamilies, and genera, and the genera of the former groups are also enumerated, and in all cases evidence is afforded of acquaintance with the most recent investigations. Not content with taking for granted the correctness of the accepted nomenclature, reference has been made to the history and

* 1. Paleontology of the Upper Missouri.—Invertebrates. By F. B. MEEK and F. V. HAYDEN, M.D. 4to. Washington, April, 1855. pp. 186, pl. 5.

2. Check List of the Invertebrate Fossils of North America.—Cretaceous and Jurassic. By F. B. MEEK. 8vo. Washington, April, 1864. pp. 40.

3. Check List id. of the Eocene and Oligocene. By T. A. CONRAD. 8vo. Washington, May, 1866. pp. 41.

4. Check List id. of the Miocene. By F. B. MEEK. 8vo. Washington, 1864. pp. 32.

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original application of each name, and, in some cases, the nomenclature has been so modified that the first impulse of many paleontologists will be to dissent therefrom, but if the rules adopted—those recommended by both the British and American Associations for the Advancement of Science—are accepted, the correctness of such modifications must be admitted. In all cases, the typical species of the genera are enumerated immediately after the diagnoses of their respective genera. Would that such a plan had always been pursued by naturalists! None but the critical investigator of such questions can know how much uncertainty and how many disputes concerning points of nomenclature would have been thereby avoided, and he who, at this late day, and in face of the lessons of the past, still refuses to thus limit a newly established group, is deserving of reproach. If, for example, the simple precaution had been taken by the Messrs. Adams in the "Genera of Recent Mollusca," of specifying the types of their numerous new subdivisions, how much confusion would have been saved! As it is, we must be at a loss to know what types to apply their names to in many cases. Shall we take the first named species? It is only by accident of its position in an alphabetical arrangement that it is so placed, and it perhaps does not agree with the diagnosis, which often defines a very artificial group combining types dissimilar, and violently severed from their allies. Again, how are we to know what species are intended, when no synonymy is given and they are for the first time associated under new genera, by the specific parts of their names alone? As has been intimated, the applicability of the diagnosis is no criterion, and, in several cases, the species intended by the authors have been mistaken. It is a question whether we would not be justified in refusing recognition to names thus proposed, save as in courtesy.

Space will not permit notice of the numerous modifications, introduced in the limitation and allocation of the genera, and of the nomenclature. We may only recall that among Trilobites, several names proposed by Barrande and others, are replaced by prior ones of Corda; among the Brachiopods, several of Pander's and other names have been reëstablished, and the proper affinities of several genera, i. e., *Myalina* Koninck, *Aviculopecten* McCoy, and forms confounded with *Monotis*, have either been first demonstrated or confirmed by reference to their microscopical structure. Of new genera, may be enumerated *Chœnomya** (Anatinidæ), *Grammatodon* (Arcidæ), *Camptonectes* Ag. (Pectinidæ), *Lioplacodes* (Viviparidæ) and *Macrophysa* (Lymnæidæ).

* It is suggested in a foot note that *Chœnomya* might be identical with *Anthracomya* Salter, but that reference could not be had to the original description of that genus: the description of Salter's genus having since come to hand, proves, however, that the two are entirely distinct.

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Of questions formerly doubtful and here apparently settled, that of the relations of the fossils, known under the names *Trigonellites* or *Aptychus,* is especially noticeable. These have been regarded as peculiar organisms, shells of Lamellibranchiates, remains of Fishes, the digestive apparatus of Gasteropods and Cephalopods, the valves of pedunculated Cirripeds, and supplementary appendages to the shell of Ammonites or their opercula, and all of these opinions have been more or less satisfactorily shown to be erroneous. Of late years, however, the belief in their pertinence to the Ammonitidæ had been gradually gaining ground. By our authors, it has been suggested that they represent the jaws of Ammonites. It is only surprising that this view had not been corroborated before, and especially after the jaws of *Nautilus* had been made known. Found often in intimate connection with Ammonitidæ and Goniatitidæ, what else could they be but the jaws? The examinations of *Nautilus* had demonstrated, that there was no such gizzard-like appendage, and no operculum, and in such respects had only confirmed what was *a priori* probable. Further it had been shown that *Nautilus* had jaws composed of an inner corneous, and external calcareous layer. The intimate relations of Nautilidæ with Goniatitidæ and Ammonitidæ being admitted, we might then expect to find analogous jaws in the latter, and it might be supposed that the search for such, would have soon culminated in the conclusion that *Trigonellites* represented them. The demonstration thereof could not, however, have been considered complete, till the discovery of the homologues of the upper as well as lower jaw of *Nautilus:* but both having now been found, and in opposition to each other, and in the aperture of the shell of *Scaphites Cheyennensis*, doubt will scarcely be entertained by any competent observer concerning their relations. Many paleontologists of late seem to have been prepared to assent to the opinion that *Aptychus* represented an operculum of *Ammonites*, and in figures it has been represented as fitting into and closing the apertures of Ammonitids with an admirable exactness,* but perhaps accuracy has, in such cases, been unintentionally somewhat

* The *Aptychus* has been represented with edges exactly applied to the walls of the chamber, but we are left to conjecture how it could be extended beyond the aperture of the adult which is much contracted by the inflection of the margin, as in *A. microstoma, A. Humphriesianus, A. Codomensis, A. Gervillii,* &c. In this dilemma, we would be obliged to assume that the "operculum" was variable in size, modified according to age, or present in some types and absent in otherwise very closely related ones—assumptions so bold that few, after due consideration, would be sufficiently brave to entertain the privilege of assuming that the duplication of the "*Aptychus*" was an adaptation to ensure its folding, for extrusion would even be denied to us, as the aperture is contracted from the distal as well as lateral margins.

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sacrificed to effect. He who would adopt the theory that *Trigonellites* or *Aptychi* are the opercula of Ammonitidæ and Goniatitidæ, must first admit that the jaws of those animals have never been discovered, and in face of the fact, that almost countless species and innumerable specimens of many have been obtained, while the jaws of other Cephalopods, much less susceptible of preservation than those of living Tetrabranchiates, have been found: he must also necessarily assume that, notwithstanding the very close resemblance of the shells, the animals must have been fundamentally dissimilar, and finally, the anomaly is presented of a *double operculum increasing in opposite directions.* When, finally, it is remembered that the opposed portions of the Aptychoid, described by our authors, exhibit essentially the same relations as to size, &c., that the jaws of *Nautilus* do, and that, like those jaws, *Aptychus* has an internal corneous and external calcareous layer, more scarcely need be said. The difference of form, however, is very great.

Of necessity, some questions of affinity of species described are left undetermined on account of the condition of the fossils, and their solution must be deferred to the future. It is doubtless for this reason, and in order not to give a new name, that the *Valvata? scabrida*, whose affinities even with the family Valvatidæ are regarded as doubtful, is retained in that genus, and *Tropidina*, which it resembles in form, is for its accommodation subordinated to subgeneric rank under *Valvata.* Elsewise, the authors would have doubtless been influenced by the peculiar characteristics of the animal, especially its lingual dentition, and also of its shell, to elevate it to a generic rank, for in the family Viviparidæ, *Lioplacodes* is generically distinguished on slighter conchological differences than those apparent between *Valvata* and *Tropidina.* If we also demur to the retention of *Dentalium* under the Cyclobranchiata; to the extension of Pulmonifera to include the operculate Pulmonates; and to the elevated rank, which is retained for the Rostriferous Gasteropods, we record our chief grounds of difference, but would add in justice to the authors, that they have simply adopted the views regarding those groups generally prevalent.

It may be stated in conclusion that the part issued has 128 quarto pages of text (besides an index of seven pages) and five plates, and if it is added that sixty-six species are described and figured, some idea may be formed of the elaborate treatment to which they are subjected. The generalizations founded on the observations recorded may be expected to appear in the concluding part.

Reverting now to the "Check Lists" above enumerated, we have in them almost a complete catalogue of the invertebrate fossils occurring in the North American beds from the dawn of

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the Jurassic to the end of the Miocene Tertiary. The species found in the Jurassic and Cretaceous formations are arranged in a strictly zoological order under those respective heads,* the subordinate divisions of neither being recognized. The Tertiary, however, is subdivided into the Eocene, Oligocene, and Miocene, and the fossils of each epoch (except the Eocene) are arranged according to their structural affinities—or rather, we should say, as those have been interpreted. Of Jurassic species, 35 are enumerated; of Cretaceous, 885; of Eocene, 766; Oligocene, 105, and of Miocene, 775,—a total of 2566 species of extinct Invertebrates of the Secondary and Tertiary ages: to this number must be added previously undescribed species, whose geological or zoological relations were undeterminable, as well as numerous Cretaceous and Tertiary types since described. From this total are also excluded the species discovered in the Triassic beds. The compilation of such lists, unaccompanied even by references to the volumes in which the species are described, is a task of no slight magnitude, especially when all the species are subjected to a critical investigation respecting their affinities, and the care and conscientiousness with which that task has been done, and the knowledge and judgement which have been brought to bear upon it, will be obvious on the most superficial examination of the lists. That there are errors of judgement; that species may be found to have been enumerated several times and even under different genera; and that faults of other kinds may be hereafter detected,—is quite possible, but such failures are inseparable from compilations of this character, although made with the most rigorous care and by the best informed; one of the happy results of such lists is that these errors will sooner be detected and rectified, and that the recurrence of similar ones in the future will, in great measure, be prevented—surely a sufficient boon if none other were furnished! The imperfect condition in which many fossils are found, the inability to examine parts of the shell even which may furnish a good clue to their affinities, the necessity of trusting in the accuracy and interpretations of describers, who may be insufficiently educated, are all elements which must produce more or less error, and generations may elapse before they can be rectified. Under these circumstances, it may not be deemed singular, if views regarding some forms are suggested, differing from those expressed in the classifications of the lists noticed.

The species of the Jurassic, a formation chiefly developed in Dakota and Idaho, have been mostly described in the Paleontology of the Upper Missouri published since the list, and therein one new species—*Viviparus Gillii*—is added.

* This is the first attempt hitherto made, to group our Cretaceous and Jurassic Invertebrates, in accordance with their zoological affinities.

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Of the more characteristic Cretaceous types, 111 species of Ammonitidæ, 40 of Inoceraminæ, 9 of *Venilia*, 8 of *Gryphæa*, 7 of *Neithea*, and 19 of *Rudista*, &c., are enumerated, and 13 new genera or subgenera are established for Cretaceous forms. Among observations on other types, is one especially deserving consideration from naturalists; "it is not probable that *any* of the species retained under the name *Fusus* in the foregoing list, belong to that genus" as properly restricted. Apparently few of the species indeed belong to the same family (Fasciolariidæ) with the true *Fusi* or *Coli*, some belonging rather to the Buccinidæ and others with the Cassidulidæ, &c. The mollusca possessing shells of a more or less subfusiform shape require a severe revision by one conversant with the anatomy of the including order; congeneric species have been widely separated from each other, while very diverse types have been combined under one genus, and from this defect the latest works have been by no means free.

The Eocene strata are grouped by Mr. Conrad under three sections—the "Lower and Medial Eocene (Shark River and Claiborne Groups)," the "Shell Bluff Group," represented by the upper part of the Claiborne Bluff, and on the Savannah river, and the "Upper Eocene, or Jackson Group," which derives its names from its development at Jackson, Miss., and which is also represented in the Carolinas, &c. By far the largest number of species is found in the Lower and Medial Eocene, and only five species have been obtained in the Shell Bluff Group: the three groups are believed to hold "few if any species in common." Of the so-called Oligocene species, all—105 in number—are found at Vicksburg, Miss.

Mr. Conrad has treated his subject with his accustomed ability, but occasionally we are led to wonder why certain combinations have been made,—under the Sycotypidæ, for example, the genus *Perissolax* is included, and the combinations of species under genera at least require explanation, before they can be understood. An ordinary observer would be able to discover no generic difference between the so-called *Ficopsis mammillatus* and the typical *Pyrulæ*.* After an examination of almost all the living species of the latter, the conclusion has been forced on us that the species in question is more nearly related to the *P. ficus* than several of the species that no one has pretended to at all isolate; yet it is not only generically separated by Mr. Conrad but united with species having, apparently, no close relation with it. The number of such inconsistencies, however, is not larger than might be expected in so long a list, and detracts little from

* The name *Pyrula* (Lam. 1799 type *Bulla ficus* L.) is provisionally adopted rather than *Sycotypus* or *Ficus*: *Sycotypus*, in the first place, is not congeneric with *Pyrula*, but was based on *Busycon canaliculatum* or *pyrum*, and Browne's names, not being binomial, can scarcely be adopted. *Ficus* is objectionable, as the name had previously been used in botany.

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the merit of the work: there are indeed few who have exhibited in their labors such sagacity in the forming of the smaller groups, among Mollusca, and the appreciation of their affinities, as Mr. Conrad.

The Miocene, commencing along our eastern border at Maryland, extends southward to South Carolina, and on the western border, it is developed in California and Oregon, while in Dakota, fresh-water deposits have been referred to that period; it is not, however, by any means certain that these several deposits are synchronous.* In the east, the southern extension of the strata has been referred to the Pliocene, but it is traceable into the northern portion as a continuous formation throughout its extent. For the enumeration of the species of this formation we are indebted to Mr. Meek, but he has in most cases adopted the views of Mr. Conrad. Among the groups that require revision, as to their systematic relations, are the families "Buccinidæ" [=Nassidæ] and Muricidæ [=Muricidæ, Buccinidæ, &c]. In the Nassidæ, some incongruous forms are associated under *Tritia*, especially *T. altilis* and *Bulliopsis*; the latter group has congeners in the Vienna Basin, &c., which have been referred to the genus *Melanopsis*. But the consideration of such questions would transcend the limits of a review. Before closing, we would, however, refer to some praiseworthy features exhibited in the publications under notice.

One rarely seen in paleontological publications, and yet extremely desirable, is the indication by the authors of the supposed affinities of all the genera introduced by them into the system. This contrasts most favorably with the negligence in such respects by many paleontologists, who describe supposed new genera as if they were isolated organisms to which nothing in the earth, or the waters under the earth, or the heavens above, was like. Such descriptions, moreover, are loaded with characters partly family, ordinal, or even classical, and partly specific combinations, which evidently indicate that the authors had no clear idea of the relations of the forms introduced; nevertheless it were to be desired that knowledge and precision in this respect could be exacted. Akin to this is the custom, when hints are offered as to affinities, of comparing to, or considering the new forms as "connecting links" between representatives of widely different groups. Without referring to any known example our meaning may be illustrated by supposing a naturalist, in making known a new type of Litorinidæ, referring to *affinities* (not anal-

* It may be here remarked, that the fossils occurring in Oregon, and first referred to the Miocene by Mr. Conrad, are now considered by him to be of Eocene age, and enumerated in his list; they are also enumerated by Mr. Meek in his list of the Miocene species, and finally, Dr. Carpenter has identified almost all the species with living forms. It is more certain that Dr. Carpenter is wrong in almost all his identifications than that Mr. Conrad was not right in the first instance.

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ogies) to the genera *Trochus*, *Bulimus* and *Phasianella:* such extreme cases are not rare in Paleontological literature, and, to say the least, are suggestive of a confusion of ideas which necessarily renders our confidence in the describers very limited. Let us hope that such errors will be more generally avoided hereafter, and that, with such bases as we have in the publications under review, worthy superstructures may be erected, and that the good examples set therein may be followed by at least our own countrymen. T. G.

ART. XLII.—*On the genus Elasmognathus;* by THEODORE GILL.

SINCE my communication on the new Tapiroid to which I have given the name *Elasmognathus Bairdii*, I have been enabled to examine skulls of four more specimens of the species, all essentially agreeing, but offering differences which perhaps indicate sexual variation. The more the skull is examined, the more does the great difference from the other *Tapiridæ* impress the observer; it resembles that of the Asiatic Tapir (*Rhinochœrus Malayanus*) rather than those of the American species (*Tapirus terrestris*, *T. pinchaque*), especially in the abbreviation of the cranial box, and apparently in the form of the maxillary bones behind, as well as of the nasal bones. The abbreviation of the cranial box is a very important peculiarity of the new type and contrasts strongly with the larger one (not only relatively but actually) of *Tapirus;* this abbreviation would seem to entail some of the differential characters, such as the lamellar form of the maxillary bones behind, &c., as the proportions in other respects are nearly similar. Among the genera of Ungulates, there are indeed no two nearly related genera which exhibit differential characters more strongly marked, or of greater value, than *Elasmognathus* and *Tapirus.* In the extent and form of the cranial box, the form and relations of the maxillary bones, the form of the nasal bones, and the *complete* osseous development of the nasal septum, those genera are widely different; and as those differences must be the coëfficients of peculiarities in the face and proboscis and of consequent modification of habits, and as they are supported by numerous minor differences, consistency in our systematic arrangements seems to require that the generic distinction of *Elasmognathus* should be recognized. Among the normal mammals, none except *Rhinoceros tichorhinus* has a nasal septum so completely ossified as *Elasmognathus.*

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ART. XLIII.—*On the action of water upon "Carbohydrates" at an elevated temperature;* by O. LOEW.

IT is well known that the carbohydrates are not decomposed with separation of carbon, at a temperature of 170° C. Cane-sugar yields at 160° levulosan and glucose, at 180° caramelan, at 200° caramel, assamar and caramelin, and at about 250° it yields with total decomposition aldehyd, aceton, acetic acid, furfurol and carbon. But the decomposition takes place quite differently if water is present. While dried sugar yields only levulosan and glucose at 160°, it is perfectly decomposed on heating with water in sealed tubes at the same temperature.

This decomposition is accompanied with the formation of carbonic acid and separation of carbon. Very nearly half of the carbon contained in the sugar employed is thus separated. If the black mass contained in the tube, which has a strong acid reaction, is distilled with water and the distillate saturated with carbonate of lead, and evaporated, a salt is obtained giving all the characteristic reactions of formic acid. I obtained the following results on analysis:

0·5800 grm. gave 0·593 sulphate of lead, 0·728 grm. gave 0·210CO_2 and 0·046 water.

	Calculated.	Found.	
Pb	69·69	69·84	=Formiate of lead.
C	8·08	7·87	
H	0·66	0·69	

There is also formed in this reaction a small quantity of humic acid.

The specific action of the water in this decomposition seems to be that of an acid; for if sugar be heated with *alcohol* at the *same* temperature, in sealed tubes, it remains perfectly unchanged; not the smallest quantity of carbon is separated. Further I have found that sugar is not decomposed by heating it with a solution of baryta in heated tubes at 170° C. Beautiful needles of sugar-baryta only are formed.

Water has the same action upon other "carbohydrates." Starch, gum, or milk-sugar heated with water to 170° for about five hours, gives formic acid, carbon and carbonic acid; gum yields the most carbonic acid. There is also formed a peculiar acid, but little soluble in water, though easily in alcohol and ether. I propose to make this acid the object of further study.

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ART. XLIV.—*Exploration of Kent's Cavern, Devonshire: Report of the Committee of the British Association, consisting of* Sir CHARLES LYELL, Bart., Professor PHILLIPS, Sir JOHN LUBBOCK, Bart., Mr. JOHN EVANS, Mr. EDWARD VIVIAN, and Mr. WILLIAM PENGELLY (Reporter).*

THE celebrated Kent's Cavern, or Kent's Hole, is about a mile due east from Torquay harbor. It is situated in a small, wooded, limestone hill on the western side of a valley which, about half a mile to the south, terminates on the northern shore of Torbay.

The hills which surround the district consist of limestone, greenstone, clay-slate, and a reddish grit or compact sandstone. The two last are traversed by veins of quartz; and, with the possible exception of the greenstone, they all belong to the Devonian system. Indeed the entire Torquay peninsula is exclusively made up of rocks of this age.

According to tradition, there were formerly four or five entrances to the cavern, of which two only were generally known, the others being merely narrow apertures or slits through which, until they were blocked up from within, the initiated were wont to enter clandestinely. The remaining two are about fifty feet apart, and occur in the face of one and the same low natural cliff, running nearly north and south, on the southeastern side of the hill. The northern entrance is in form a rude triangle, about six feet high and eight feet wide at the base. The southern is a natural and tolerably symmetrical arch, 9½ feet wide at the base, and six feet high. Its form is due partly to a gentle curvature of the strata—the apex of the opening being in the anticlinal axis—and partly to the actual removal, by natural causes, of portions of the limestone beds; the base of the opening, or chord of the arc, consists of undisturbed limestone; so that the entrance may be aptly compared to the mouth of an oven.

From the time of the researches and discoveries which, forty years ago, rendered the cavern famous, to the commencement of the exploration under the auspices of this Association, the southern entrance has been blocked up, the northern alone being used by visitors. The base of the latter is about 189 feet above the level of mean tide,† whilst that of the former is about four feet lower.

The cavern has been known from time immemorial. Even tradition fails to reach back to the date of its discovery. It did

* From the Report of the British Association for 1865.

† A "bench mark" of the Ordnance Survey in the road from Torquay to Ilsham farm, and which is at no great distance from the cavern, is, as Col. Sir H. James kindly informs me, 131·629 feet above the level of mean tide at Liverpool. By pocket aneroid, the base of the northern entrance of the cavern is 57·5 feet above this mark.—W. P.

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not, however, attract the attention of scientific inquirers until September, 1824, when Mr. Northmore visited it with the double object, as he stated, "of discovering organic remains, and of ascertaining the existence of a temple of Mithras," and he declared himself "happy to say that he was successful in both objects." He was speedily followed by Mr. W. C. Trevilyan, who, according to the Rev. Mr. M'Enery, "was the first that obtained any results of value to science." Mr. M'Enery, whose name must be forever associated with the cavern, first visited it in the summer of 1825. He was at that time quite inexperienced in cavern researches; for he states that the party which had been induced to accompany was a large one, and that on entering the cavern he "was the last of the train, for he could not divest himself of certain undefinable sensations, it being his first visit to a scene of this nature." The visit was a memorable one; for, separating himself from his companions, and devoting himself to what he conjectured to be a favorable spot, he found several teeth and bones. He thus describes his feelings on the occasion:—"They were the first fossil teeth I had ever seen, and as I laid my hand on these relics of extinct races, and witnesses of an order of things which passed away with them, I shrank back involuntarily; though not insensible to the excitement attending new discoveries, I am not ashamed to own, that in the presence of these remains I felt more of awe than joy." He at once communicated his discovery to Dr. Buckland, and with great energy followed up his "good fortune" for several years. So far as can be ascertained from his memoranda, the date of his latest visit was August 14th, 1829.

Though he at one time intended to publish a narrative of his labors and discoveries, and had made arrangements for the requisite illustrations, the intention was unfortunately abandoned. After his decease, it was feared that his manuscripts had been destroyed or lost; but after experiencing a variety of fortune they passed into the hands of Mr. Vivian of Torquay, who from them compiled a Memoir which was published in 1859.*

In 1840, Mr. Godwin-Austen read a paper before the Geological Society of London, on the "Bone Caves of Devonshir" when he described the results of his investigations in Kent's Hole.

In 1846, the Torquay Natural History Society appointed a committee to conduct an exploration of a small portion of the cavern. Though their object was mainly to obtain specimens for the Society's Museum, very careful attention was given to the positions and associations of all the articles found. A paper embodying the results of this investigation was drawn up

* Cavern Researches. Simpkin, Marshall and Co., 1859.

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by Mr. Vivian, a member of the committee, and read in 1847 before the Geological Society of London. A mention of this communication appeared in the 3d volume of the Quarterly Journal of the Society.

Though it may be doubted, perhaps, whether any of the foregoing explorations were conducted with that rigid observance of method which is now held to be necessary, all the explorers are unanimous in stating that they found flint "implements" mixed up with the remains of extinct animals.

In 1858, the results of the systematic and careful exploration of Brixham Cavern, on the opposite shore of Torbay, induced the scientific world to suspect that the alleged discoveries which, from time to time during a quarter of a century, had been reported from Kent's Hole, might, after all, be entitled to a place amongst the verities of science; and from that time various proposals for further investigations have been made. As is well known, these suggestions took a definite form at the last Meeting of this Association, when a liberal grant of money was made, and a committee was appointed for the purpose of further exploration. It is the object of this communication to state what up to this time the results have been, so far as they are at present determined.

The committee have great pleasure in stating that, in reply to their application for permission to make the proposed investigation, the proprietor, Sir L. Palk, Bart., M.P., assured them most promptly that it would "give him great pleasure to place every facility in their hands." He placed the cavern in their exclusive custody, and suggested the most satisfactory arrangement for the ultimate disposal of such objects of interest as might be found.

Though large portions of the deposits were broken up by Mr. M'Enery and his successors, there is still within the cavern a very considerable amount of virgin ground. The committee, however, were desirous of selecting an area in which not only were the deposits certainly intact, but which would not present any very great difficulties in working. After a visit of inspection it was decided to undertake the exploration of the large chamber into which the southern entrance immediately opens. The mode of investigation was laid down, trustworthy and intelligent workmen were engaged (Mr. Charles Keeping, brother of the well-known fossil collector, being the chief), and the work, consigned to the superintendence of the two resident members of the committee, Mr. Vivian and the Honorary Secretary, was commenced on March 28th of the present year.

Immediately outside the cave lay a considerable talus of earth and stones, the upper portion of which, at least, is believed to have been thrown out by Mr. M'Enery, who conducted his re-

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searches through the northern opening. It was necessary to cut through this mass, in order to reach and make available the entrance which the committee had selected for their operations. This material was very carefully examined, partly for the purpose of detecting any objects of interest which it might contain, and partly as an initiatory exercise for the workmen.

The cavern is in no part subject to any considerable amount of drip; and no portion of it is drier than the chamber selected for exploration. Since the commencement of the work unusually heavy rains have fallen in the district, but water has entered through the roof at very few points only, and in no instance in such an amount as to produce discomfort or inconvenience.

The following is the succession of deposits, in descending order, which the chamber contained.

1st. Huge blocks of limestone which had manifestly fallen from the roof. Many of them required blasting to effect their removal; and in several instances it was necessary to blast even the masses into which they were by this means divided. One of the blocks measured 11 feet long, 5½ broad, and 2½ thick; hence it contained upward of 100 cubic feet, and must have weighed fully seven tons. In some cases two or three of them lay one on another, and, in a few instances, were firmly cemented together by a separate cake of stalagmite between each pair; whilst others lay unconformably with considerable interspaces. Occasionally, what appeared to be a boss or dome of stalagmite proved to be a block, or two or three small blocks, of limestone invested on all sides with a stalagmitic sheet. Certain masses, lying at some distance from a drop, were without even a trace of stalagmite.

2d. Beneath these limestone blocks there was a layer of mould of an almost black color. It varied from a few inches to upward of a foot in depth.

3d. Underneath the black soil came a cake of stalagmitic breccia, made up of comparatively small fragments of limestone so very firmly cemented together with carbonate of lime as occasionally to require blasting. It was rarely less, but not unfrequently much more, than a foot thick. Everywhere it was firmly attached to the walls, and it occasionally extended completely across the chamber. Not unfrequently, however, the center of the chamber was altogether destitute of this breccia, in some instances, because there is no drip near the area, in others, because it was intercepted by an overlying limestone block.

4th. The breccia is succeeded by the ordinary reddish cave-loam, which contains a large number of limestone fragments, varying in dimensions from bits not larger than sixpences, to

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masses but little smaller than those which lay on the surface. They lie at all angles without anything like symmetrical arrangement. In fact the entire deposit is without any approach to stratification. Many of the stones are partially encrusted with calcareous matter, and not unfrequently loam, stones, and splinters of bones are cemented by the same substance into a very tough breccia. The presence of a calcareous drip is more or less traceable everywhere. Hitherto the cave-earth has been excavated to the depth of four feet only. How far it extends below this, or what may be beneath it, is at present unknown. Where it is not covered with the stalagmitic breccia, the black soil lies immediately on it; but the line of junction is everywhere sharply defined. In no instance do the two commingle.

Since the large masses of limestone occur at all levels in the cave-earth as well as everywhere above it, it is obvious that whatever may be the cause to which their fall is attributable, they cannot be referred to any one and the same period. They fell from time to time throughout the accumulation of the cave-earth, they continued to fall whilst the stalagmitic breccia was in process of formation, as well as during the introduction of the black mould, and they are amongst the most recent phenomena which the cavern presents. And even of those which lie on the surface, there is conclusive evidence that in some cases a considerable interval of time must have elapsed between the fall of two blocks lying one on the other—an interval sufficiently great for the formation of the cake of stalagmite between them, and which is sometimes fully six inches thick. There can be little doubt that some of them fell very recently, even when measured by human standards.

It is by no means easy to determine the cause which threw them down. To call in the aid of convulsion seems undesirable, since it would be necessary to do so very frequently. Moreover, it may be doubted whether anything short of a violent earthquake would be equal to the effect. Though the roof of the chamber is of very great span and entirely unsupported, and though it presents appearances which are not calculated to inspire confidence, the violent concussions produced by the frequent blastings already mentioned, blastings which not unfrequently throw masses of limestone, weighing upward of a ton, to a distance of several feet, have never brought down even a splinter.

The fall of the blocks has sometimes been attributed to changes of dimensions in the roof arising from changes of temperature; but the fact that the cavern temperature is all but constant throughout the year, seems fatal to this hypothesis.

The masses lying on the surface were a sufficient guarantee that the deposits beneath them remained intact. There can be

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no doubt that they are at once a proof and the cause of the undisturbed character of the soil they cover. A portion of the cavern so easily accessible as is this chamber, would not have been spared by Mr. M'Enery, but on account of some great difficulty or discouragement; and in fact he states that the fallen masses completely foiled him in his attempts to make explorations in it, excepting in one branch some distance south of the area selected by the committee. Their own characters, moreover, render it absolutely certain that the deposits have never been violated.

The following is the method of exploration which has been observed from the commencement, and which it is believed affords a simple and correct method of determining the exact position of every object which has been found.

1st. The black soil accessible between the masses of limestone on the surface was carefully examined and removed.

2d. The limestone blocks occupying the surface of the deposits were blasted and otherwise broken up, and taken out of the cavern.

3d. A line, termed the "datum line," is stretched horizontally from a fixed point at the entrance to another at the back of the chamber.

4th. Lines, one foot apart, are drawn at right angles to the datum line, and therefore parallel to one another, across the chamber so as to divide the surface of the deposit into belts termed "parallels."

5th. In each parallel the black mould which the limestone masses had covered is first examined and removed, and then the stalagmitic breccia, so as to lay bare the surface of the cave-earth.

6th. Horizontal lines, a foot apart, are then drawn from side to side across the vertical face of the section so as to divide the parallel into four layers or "levels," each a foot deep.

Finally, each level is divided into lengths, called "yards," each three feet long, and measured right and left from the datum line as an axis of abscissæ.

In fine, the cave-earth is excavated in vertical slices or parallels four feet high, one foot thick, and as long as the chamber is broad where this breadth does not exceed 30 feet. Each parallel is taken out in levels one foot high, and each level in horizontal prisms three feet long and a foot square in the section, so that each contains three cubic feet of material.

This material, after being carefully examined *in situ* by candlelight, is taken to the doorway and reëxamined by daylight, after which it is at once removed without the cavern. A box is appropriated to each yard exclusively, and in it are placed all the objects of interest which the prism yields. The boxes, each

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having a label containing the data necessary for defining the situation of its contents, are daily sent to the Honorary Secretary of the committee, by whom the specimens are at once cleaned and packed in fresh boxes. The labels are numbered and packed with the specimens to which they respectively belong, and a record of the day's work is entered in a diary.

The same method is followed in the examination of the black mould, and also of the stalagmitic breccia, with the single exception that in these cases the parallels are not divided into levels and yards.

With very rare exceptions the cavern has been visited daily by one, and frequently by both of the superintendents; and monthly reports of progress have been regularly forwarded to Sir Charles Lyell, the chairman of the committee.

Though it would be premature to attempt anything like an exhaustive list, it may be of interest to furnish a brief and general account of the objects which have been found.

Of the articles met with in the black mould, those occurring *between* the fallen masses of limestone have been kept distinct from such as have been detected *beneath* them. Such a division, however, is not rendered necessary by the characters of the objects themselves, and will not be attended to on the present occasion. In this category also may be placed the greater number of the specimens found in the talus outside the cavern. The collection is of a various miscellaneous nature. It consists of stones of various kinds, human industrial remains, charred wood, bones of various animals, marine and land shells, and the broken shells of hazel-nuts. It passes from the rabbit's nest lined with clean dry fur and containing a couple of fresh green ivy-leaves, and numberless fragments of wine and porter bottles flung away by parties who have visited the cavern mainly from a love of frolic, back to the age of bronze implements and of flint-flakes, and probably represents from fifteen hundred to two thousand years.

The stones are in most cases well rounded, and, at least, some of them are of marine origin, since they are distinctly lithodomized. They consist of limestone, quartz, red grit, greenstone, and flint; all except the last derivable from the rocks of the immediate district, and were probably obtained from the neighboring beaches, where also the flints were perhaps found; for though there is no flint *in situ* within five miles, it is a well-known fact that such pebbles are met with on existing beaches at much greater distances from any known accumulation of flints in place. The rounded stones are extremely numerous in the black mould, and were undoubtedly selected and taken to the cavern; but for what purpose it may not be easy to determine. There are also several pieces of hard greenish-grey grit of an

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elongated form, which were perhaps used as whetstones. Angular pieces of slate are also numerous. They are probably fragments of articles fashioned by man, as occasionally a piece is met with which is obviously a portion of a curvilineal plate. Such plates are mentioned by Mr. M'Enery, who supposes them to have been used as covers for earthenware vessels. The human industrial remains consist of articles in bronze and in bone, pottery, spindle-whorls, and flint-flakes. The bronze articles are a fibula, the bowl and part of the stem of a spoon, a spear head, a fragment of a socketed celt, two or three rings, one coil of a helical spring, a pin about $3\frac{3}{4}$ inches long, and an object resembling a horseshoe in form, but not more than an inch long. In this connection may be mentioned a lump of metal which, from its general appearance, would be termed copper ore, but from its interior, a small portion of which has been exposed accidentally, it is probably native copper, or a mass of metal which has been smelted. A similar mass mentioned by Mr. M'Enery, is said to have been analyzed "by Mr. Phillips and found to be pure virgin ore." Much of the pottery, excepting one small piece, undoubtedly Samian, is extremely coarse, and in most cases it is unglazed. A large number of fragments have been found, but nothing approaching a perfect vessel. They are generally ornamented, and from the different patterns, as well as from other facts, it may be concluded that they represent a considerable number of utensils. One piece probably formed part of a vessel in which things were burnt, as on its inner surface there is a firm admixture of clay and small bits of charcoal. Much of the pottery is without doubt of Roman age.

The objects fashioned in bone are a comb, which in size and outline resembles a common shoe-lifter having teeth cut in the broad end; a spoon, neatly formed of a portion of a rib, and measuring about 6 inches long and $\frac{9}{16}$ths of an inch broad; a chisel about $2\frac{8}{16}$ths inches in length, and at its broad end $\frac{4}{16}$ths of an inch in width; a wedge, somewhat rudely fashioned out of a horn or antler; two small fragments which appear to be portions of combs, and one of which bears traces of ornamentation; and an article about 3 inches long, apparently the handle of some tool.

The spindle-whorls are formed of different materials, such as Devonian red grit, one of the harder varieties of Triassic sandstone (rocks abundant in the neighborhood), a somewhat coarse, greenish, schistose rock not found near the district, and Kimmeridge coal. They differ somewhat in dimensions and in workmanship; some being well finished, whilst others are so roughly made as to render it safer perhaps to call them simply "holed stones." With them may be mentioned a large bead, which ap-

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pears to consist of amber or some analogous substance; and a small, holed, ellipsoidal fragment of limestone, which was perforated probably by some lithodomous mollusk.

The flint-flakes are four in number, two of dark and two of light or white flint, the latter being the best formed. The light color is more or less superficial, the center being of a dark gray.

The charred wood is very abundant. Some specimens are undistinguishable from prepared charcoal, whilst others are obviously nothing more than partially burnt sticks, some of them of considerable size.

Bones are extremely numerous. They are more or less discolored, and have lost a considerable portion of their weight.

It may be doubted whether the entire elements of any skeleton have been found lying together. Amongst them there are the relics of pig, deer, sheep, fox, wolf (?), bat, hare, rabbit, with smaller rodents, birds, and various kinds of fish. Some of them appear to have been exposed to the action of fire.

The land shells are principally various kinds of snail, the larger forms being the most prevalent. They occur in all stages of growth, and thus render it probable that they had established a colony in the cavern. Amongst the marine shells are the limpet, whelk, oyster, cockle, mussel, pecten, solen or razor-shell, and the internal shell of the cuttle-fish, *Sepia officinalis*. From the unrubbed condition of the last, it was probably not found cast ashore on the beach, but taken directly from the cephalopod to which it belonged.

The source of the shells of hazel-nuts is not far to seek. They were no doubt obtained from the wood in which the cavern is situated, and were perhaps carried in by small animals whose homes were under the fallen masses of limestone where the shells were found. Most of them are perforated at one end.

In passing below the black mould we first encounter the stalagmitic breccia. This the workmen carefully break into small fragments, in order to detect any articles of interest imbedded in it. The search, though not very productive, has not been quite fruitless. In the breccia have been found charred wood, marine and land shells, and bones of various animals, some of which perhaps are extinct.

Immediately beneath this cake we enter the red cave-loam, and at once find ourselves amongst the relics of several species of extinct animals. The only differences in the four successive levels in which, as already stated, the red loam is taken out are simply that the first or uppermost is the poorest, and the third, perhaps, the richest in osseous remains; and that the three lower levels contain a large amount of minutely comminuted bone, of which there are very few instances in the uppermost foot. In other respects the levels are the same—everywhere the

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same in the materials which form the staple of the deposit; in the occurrence of pebbles of various kinds of rock, which differ from those in the overlying black mould only in being less numerous; in the presence of bones in the same condition and representing the same species of animals; and in yielding "flint implements" of the same types. It will not be necessary, therefore, to describe each level separately or in detail.

The bones found below the stalagmite are heavier than those met with above it. This distinction is so well marked and so constant as to be characteristic. It would be easy to assign them to their respective deposits by their specific weights alone. Most of those from the red loam are but little discolored, indeed some of them are of chalk-like whiteness. A few, however, occur here and there which have undergone a considerable amount of discoloration, a consequence, probably, and also a proof of a greater degree of exposure before their inhumation. On most of the latter, certain lines and patches of lighter color not unfrequently present themselves, which may be likened to such as are sometimes left by mosses or lichens on objects of which they have grown.

A large number of bones, including jaws, teeth, and horns, are scored with teeth-marks, clearly the work of animals of different kinds. Some of the long bones are split longitudinally. Many appear to have been rolled, including most of those which have been gnawed; and in the case of the latter, it is tolerably obvious that the rolling was subsequent to the gnawing. Some of those found beneath the large masses of fallen limestone are in a crushed condition, and thus apparently attest the fact that the deposit on which they lay, and on which the blocks fell, was of compact nature, and capable of firm resistance.

The minutely comminuted bone already spoken of, is commonly found converted with loam and stones into a firm breccia. Not unfrequently, however, it occupies the hollow cavities of some of the larger bones. With it there sometimes occurs a cream-colored substance, which in a few instances has been met also in the form of small detached lumps having a low specific gravity. This, as well as some of the comminuted bone, has been supposed to be of fæcal origin.

In cleaning the bones it is frequently found to be impossible to remove entirely the earthy matter from them. They are at least partially invested with a thin film, which defies the brush and water. On drying, however, this matter commonly scales off, and proves to be a paste or paint composed of loam and carbonate of lime, the latter probably derived from drip from the roof.

Large portions of the osseous remains occur in the forms of fragments and mere splinters. The identifiable parts are chiefly

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teeth, which are extremely numerous. Amongst the Mammals represented, there are certainly the Cave-bear, Cave-lion, Cave-hyæna, Fox, Horse (probably more than one species), Ox, several species of Deer, the tichorhine Rhinoceros, and Mammoth. Remains of the Hyæna are probably the most abundant, after which come those of Rhinoceros and Horse. The relics of the Mammoths (both molars and tusks) are those of very young individuals.

It has already been hinted that "flint implements" occur everywhere in the cave-earth mixed up with the remains of extinct Mammals. Several of them were found in the presence of, and some of them by, the superintendents. Like the bones, they are at least abundant in the uppermost foot, and occur in greatest numbers in the lowest zones. Altogether, and without reckoning doubtful specimens and numerous chips, nearly thirty "implements" have been dug out. Though the designation of "flint" is given to all, some of them are perhaps of chert. Of the flints properly so called, some are of a dark, and others of a light-grey color, whilst a third kind are almost white, and have a porcellanous aspect. With the exception of three, they are all of the kinds known as flakes—flat on one side, and more or less carinated on the other. Some of them are fragments only, others were found broken in the deposit with the parts lying in contact, whilst others again are perfect. Some of the broken specimens of the white variety show that they are not of this color throughout their entire mass, but have a dark central axis or core. The flakes agree in character with those in the black overlying mould. The excepted three are of chert, and are worked on both sides. They were found in the second, third, and fourth levels; one in each. That from the second foot is about 4¾ inches long, and, where widest, 2½ broad. At one end it tapers to a point, and narrows to no more than ¾ of an inch at the other. In outline it is rudely a segment of a curvilineal figure, and is slightly falciform. The inner or concave margin is the cutting edge. Unfortunately the tip of the pointed end was broken off after exhumation. Those from the third and fourth levels are more highly wrought "implements." They are worked to an edge around the entire perimeter. In outline they are rather ovoid than elliptical, being narrower at one end than at the other. That from the third foot measures 4½ inches in length, and its greatest breadth and thickness are respectively 3¼ inches and ¾ of an inch. That found in the fourth zone, the lowest yet reached, is the most elaborately finished "implement" of the series. It is lighter in color and somewhat smaller than the preceding two, its dimensions being 3½ inches long, 2½ broad, and ¾ in thickness.

Without intending at present to enter on the consideration of

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all the bearings of the entire evidence produced, the committee feel at liberty to express their conviction that it is totally impossible to doubt either the human origin of the "implements," or their inosculation, in undisturbed soil, with the remains of the Mammoth, the Cave-bear, and their extinct contemporaries.

Nor are these the only indications of human existence found in the cave-earth. Several small pieces of burnt bone have been met with in the red loam, some of them loose and detached, others of small size and incorporated in the breccia composed of loam, stones, and comminuted bone.

Mention has been made already of the occurrence in the cave-earth of rounded stones not derivable from the limestone hill in which the cavern is situated. It seems probable that at least some of them were selected and taken there by man; though it may not be easy, perhaps, to determine in all cases for what purpose. But, waiving this point, there are two stones which must not be hastily dismissed. The first of them is 4¾ inches long, and something less than one inch square in the section. It is a mass of hard purplish-grey grit, and is undoubtedly a whetstone, or rather a portion of one. It was found in the first level of the cave-earth, in a small recess or cavity in the northern wall of the chamber, immediately beneath a projecting stratum of limestone *in situ*. In this cavity the stone stood with its longest axis vertical. The superintendents were inclined to the opinion that it had slipped through a hole into the cavity at a comparatively recent date; and they diligently set to work to find the means of its ingress. Here, however, they were completely foiled. There was no hole or passage, vertical or lateral, by which the cavity could have been entered. Not only, as has been said, was there a thick stratum of limestone *in situ* immediately over the recess, but over this again, as well as over the red loam, there was a thick compact mass of stalagmitic breccia, consisting of large and small pieces of limestone firmly cemented, and having a height of fully eight feet; the whole of which was removed before the cavity was disclosed or its existence suspected.

The second stone is a rude flattened spheroid, formed from a pebble of coarse, hard, red sandstone, and apparently used for breaking or crushing. Its diameters measure 2¾ and 1¾ inches. It was found in the second level of the red cave-earth, over which lay an enormous block of limestone, but no stalagmite.

In addition to the pleasure which always attends scientific discovery, the committee have had the gratification of confirming most of the statements of their predecessors. Any differences observable between the statements now made and those of the earlier investigators arise from defective, not conflicting evidence. For example, the committee have not yet been so fortunate as

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to find the remains of *Machairodus latidens*, mentioned and figured by Mr. M'Enery,* nor of *Hippotamus major*, alluded to by Prof. Owen† as occurring in the cavern; nor have they found anything in the least degree calculated to bring the statements alluded to into discredit. Again, so far as their researches have gone, the committee have not, like Mr. Godwin-Austen, found the bones of man mixed up, in undisturbed soil, with those of extinct animals;‡ it will be seen, however, that there is no *à priori* improbability in the statement of the distinguished geologist just mentioned; and the committee would remind such as may be disposed to attach importance to the fact that men's bones are not forthcoming as readily as their implements, that in the black mould, as well as in the red loam of the cavern, the only indication of man's existence are remnants of his handiwork. Pottery, implements and ornaments in bone, metal, and stone, the remnants of his fires, and the relics of his feasts are numerous, and betoken the lapse of at least two milleniums; but here, as well as in the older deposits below, the committee have met with no vestige of his osseous system.

In conclusion, the committee would observe that the value of their labors is not to be measured by the discoveries, or rather the rediscoveries, which they have made. They have not only disinterred a valuable body of fact, but with it a confirmation of the concurrent statements of M'Enery, Godwin-Austen, and the committee of the Torquay Natural History Society; and have thereby more than doubled the amount of trustworthy evidence which they have themselves produced.

ART. XLV.—*Additional Notice of the Cohahuila Meteoric Iron;* by CHARLES UPHAM SHEPARD.

PROF. F. SHEPHERD having put me in communication with Maj. E. M. Hamilton, in reference to the locality of Bonanza, New Mexico, I have derived from this persevering explorer several interesting particulars concerning these extraordinary masses that appear worthy of publicity.

Major Hamilton states that Bonanza is about thirty or forty miles north of Santa Rosa, but much farther to the west. Residents of the vicinity told him, it had only once before been visited by any traveller, and this was fifteen years ago, when an Englishman had been deputed thither in an official capacity, to determine whether the iron could be applied to any useful pur-

* Cavern Researches, p. 32, and plate F. (8vo edition).
† British Fossil Mammals and Birds, p. 410 (1846).
‡ Trans. Geol. Soc., Second Series, vol. vi, part 2, pp. 444 & 446.

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pose. He reported it as having no value, for the reason that it would cost more to divide the masses, sufficiently to fit them for transportation, than the metal was worth.

Major Hamilton saw thirteen pieces, twelve of which had never been removed, and one small mass of about seventy-five pounds, that had been carried to the village of Santa Rosa. The area within which the twelve masses lie, is between one and two miles in diameter.

The largest mass projects two, or two and a half feet above the ground, and is some three feet long, and a little less in width. How far it is buried in the earth is unknown. Their surfaces are all smooth, without offering any projecting points. They are quite black and entirely free from rust. In shape, they are more or less spherical, and much resemble the time-worn boulders in the beds of rivers. Some of the smaller of them, are estimated to weigh between two and three thousand pounds.

Major Hamilton thinks it might be possible to cut off pieces of a few pounds weight, provided suitable tools for the purpose could be procured, though the operation would be attended with much difficulty.

The smaller masses might be transported across the Rio Grand into the United States, at an expense of fifteen hundred dollars each. The Mexican authorities would have no objections to their removal as they attach no value whatever to them.

Analysis.—The fragment analyzed by me, weighed 6·04 grm., and had a specific gravity of 7·825.

Its solution in hydrochloric acid, gave no indication of the presence of sulphur. The Rhabdite crystals, which in microscopic needle-points were quite abundant in the cold solution, gradually disappeared on the addition of nitric acid, leaving only a very minute quantity of a white granular powder, supposed to be silicate of magnesia. It amounted to only 0·001 per cent. The composition of the mass was,

Iron, - - - - - - - -	97·900
Nickel, with traces of chromuim, cobalt, magnesium and phosphorus,	2·100

The phosphorus, as determined upon seven gram. of the peroxyd of iron precipitate, was less than eight parts in 10·000. No search was made for tin or copper.

As I have not yet been able to procure a polished slice of the iron, I can add nothing concerning the Widman figures. If they exist, they will be extremely fine, and probably resemble those of the Braunau iron.

Amherst, March 20, 1867.

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SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the conversion of dynamical into electrical force without the aid of permanent magnetism.*—The magneto-electric machine of Mr. Wilde has been briefly described in a former notice. A modification of this apparatus which possesses much theoretic interest has been contrived by the brothers W. and C. W. Siemens, and at about the same time and independently by Wheatstone. In these machines the steel magnets of the generating or primary magneto-electric machine are replaced by electro-magnets. The electro-magnets are first charged by a galvanic battery or other rheomotor, the armature is then caused to rotate, and the battery is removed, when the magnetic action continues to accumulate without its aid. Instead of employing a battery the soft iron of the electro-magnet may be touched by a permanent magnet. In practice this is not necessary, as the residual magnetism of the iron is sufficient. In Wheatstone's apparatus the wires covering the electro-magnets and those surrounding the armature are connected, so that the current, which is made to move in one direction, acts upon the electro-magnet in such a manner as to increase its existing polarity. The force required to turn the armature then becomes vastly increased, as well as the intensity of induced current. In this case also the residual magnetism of the iron is the primary cause of the current which then goes on increasing up to a maximum, at the expense of course of a certain amount of work expended in producing rotation. When a cross wire is placed so as to divert a portion of the current from the electro-magnet a remarkable increase in the heating and magnetizing power of the current is observed. Wheatstone accounts for this increase by supposing that the current passing through the armature branch and cross wire experiences a much less resistance than if it had passed through the armature and electro-magnet branches, and though the electro-motive force is less, the resistance having been rendered less in a greater ratio, the resultant effect is greater. In conclusion Wheatstone points out the analogy between the augmentation of the power of a weak magnet by means of an inductive action produced by itself, and the accumulation of power shown in the electrical machines of Holtz and others, in which a very small quantity of electricity is made by a series of inductive actions to equal or exceed the effects of the most powerful machines of the ordinary construction. —*Proc. of the Royal Society*, xv, 367, 369. W. G.

2. *New applications of methods of reduction in organic chemistry.*—Berthelot has studied the action of iodhydric acid upon a variety of organic compounds, and has greatly extended our knowledge of the transformations produced by this valuable reagent, the introduction of which, it will be remembered, is due to himself. The experiments were conducted by introducing the organic matter to be operated on into a tube with a very concentrated solution of iodhydric acid, sealing the tube and heating to a temperature of 275° C. In this manner the iodid, bromid, and chlorid of ethylene yield hydruret of ethylene, haloid acid, and free iodine, the reaction in the case of the iodid being represented by the equation

$$C_4H_4I_2+2HI=C_4H_6+2I_2,$$

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and in the case of the bromid of ethylene by the equation

$$C_4H_4Br_2+4HI=C_4H_6+2HBr+4I_2.$$

In like manner di-iodhydrate of acetylene, $C_4H_2(2HI)$, and iodid of ethyl, C_4H_5I, yield hydruret of ethylene and free iodine. Iodid of allyl yields hydruret of propylene, according to the equation

$$C_6H_5I+3HI=C_6H_8+2I_2.$$

Iodhydric acid acts even upon perchlorinated compounds; thus sesquichlorid of carbon, C_4Cl_6, reacts with it according to the equation

$$C_4Cl_6+12HI=C_4H_6+6HCl+6I_2.$$

All the hydrocarbons capable of uniting directly with iodhydric acid, as for instance all the ethylenes and acetenes, $C_{2n}H_{2n}$ and $C_{2n}H_{2n-2}$, first unite with iodhydric acid, and afterward by the action of an excess of the acid upon the new compound formed, yield a new hydrocarbon and free iodine.

Alcohols treated in the same manner yield first the iodids of the radicals and these then react with iodhydric acid in the manner explained above. Thus the first action of iodhydric acid upon common alcohol may be represented by the equation

$$C_4H_6O_2+4HI=C_4H_6+H_2O_2+2I_2,$$

iodid of ethyl being an intermediate product. In like manner glycerine yields hydruret of propylene.

Ethers derived from the oxacids are first decomposed with formation of an iodid of the radical and regeneration of the oxacid; the iodid and oxacid are then separately acted on by the excess of free iodhydric acid. Thus methyl-formic ether and iodhydric acid react according to the equation

$$C_2H_2(C_2H_2O_4)+2HI=C_2O_2+C_2H_4+H_2O_2+I_2.$$

Common aldehyd yields hydruret of ethylene mixed with hydrogen and probably with some marsh-gas. Acetone gives hydruret of propylene according to the equation

$$C_6H_6O_2+4HI=C_6H_8+H_2O_2+2I_2,$$

but the hydruret of propylene undergoes a partial decomposition, probably according to the equation

$$C_6H_8+H_2=C_4H_6+C_2H_4.$$

Organic acids treated with iodhydric acid are reduced to formenes containing the same quantity of carbon as the acid, provided that these are sufficiently stable to resist a temperature of 275° C. Thus acetic acid reacts according to the equation

$$C_4H_4O_4+6HI=C_4H_6+2H_2O_2+3I_2.$$

Succinic acid, like butyric acid, yields hydruret of butylene;

$$C_8H_6O_8+12HI=C_8H_{10}+4H_2O_2+6I_2.$$

The author remarks that the facts mentioned above furnish a general method of reproducing the fundamental hydrocarbon of each series by means of all the bodies in the series. Thus hydruret of ethylene, $C_4H_4(H_2)$, yields by replacement $C_4H_4(Cl_2)$, $C_4H_4(HI)$, $C_4H_4(H_2O_2)$, $C_4H_4(O_4)$, and $C_4H_2(O_4)(O_4)$, in each the substitution being

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by equal volumes. All these compounds, by the reducing action of iodhydric acid, reproduce the original hydrocarbon, C_4H_6.—*Bull. de la Société Chimique*, Janvier, 1867, p. 53. W. G.

3. *On the monatomic nitriles.*—The monatomic nitriles may be regarded as primary monamines, the three atoms of hydrogen in ammonia being replaced by one atom of a triatomic radical. L. Henry has shown that this view is supported by several new and interesting facts. Thus acetonitrile, $(C_2H_3)'''N$, readily unites with dry bromhydric and iodhydric acids with production of intense heat. The resulting salts are solid crystalline white bodies, soluble in alcohol but insoluble in ether. They are rapidly decomposed by water or moist air, forming acetic acid and salts of ammonia. Benzonitrile gives analogous compounds. Sulphocyanic acid and sulphocyanid of ethyl may also be referred to the type of ammonia, like the corresponding cyanic acid and cyanid of ethyl. The sulphocyanids of ethyl and allyl combine readily with dry bromhydric and iodhydric acids, giving white crystalline bodies decomposed by water.—*Bull. de la Soc. Chim.*, Janvier, 1867, p. 85. W. G.

4. *On graphitoid boron.*—Wöhler has obtained the so-called graphitoid boron, discovered by Deville and himself, in sufficient quantity for analysis, and has found that the substance in question is not boron but a compound of boron and aluminum. The compound is always formed in preparing crystallized boron or by fusing aluminum in the vapor of chlorid of boron. The borid crystallizes in very thin pale copper-colored six-sided tables which, according to Prof. W. H. Miller, are monoclinic. It does not burn in the air but burns in chlorine with brilliancy, forming chlorid of aluminum and chlorid of boron. Two analyses led to the formula AlB_2.—*Ann. der Chemie und Pharm.*, cxli, 268. W. G.

5. *On the constitution of mellitic acid.*—Bæyer and Scheibler have found that mellitic acid is six-basic and has the constitution of benzol, in which six atoms of hydrogen are replaced by six of carbonyl, $C\Theta_2H$, so that its formula is $C_6(C\Theta_2H)_6$. When heated with lime it is completely decomposed into carbonic acid and benzol. With sodium amalgam mellitic acid takes up six atoms of hydrogen and forms the six-basic acid, $C_6H_6(C\Theta_2H)_6$, which, when heated with sulphuric acid, yields a four-basic acid, $C_6H_2(C\Theta_2H)_4$. This can take up four atoms of hydrogen to form a new acid, which, when treated with sulphuric acid, again loses carbonic acid. The final product of these transformations is benzoic acid. The authors beg chemists who may possess a stock of mellite to supply them with material for their investigation.—*Ann. der Chemie und Pharm.*, cxli, 271. W. G.

6. *On the cyanic ethers.*—Gal has studied the action of chlorhydric and bromhydric acids upon cyanic ether. The dry ether absorbs chlorhydric acid gas, and by distillation a liquid is obtained which has a penetrating smell, fumes slightly in the air, and boils between 108° and 112° C. The author gives to this body the formula $C_4H_5O.C_2NO.HCl$, which may be referred to the type of chlorid of ammonium, and written $N\left\{\begin{matrix} \overset{\|}{C_2O_2} \\ C_4H_5 \\ H \end{matrix}\right\}Cl$. Water decomposes this substance, forming chlorid of

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ethylammonium and carbonic acid, the reaction being expressed by the equation

$$C_4H_5O.C_2NO.HCl+2HO=C_4H_7N,HCl+2CO_2.$$

Bromhydric acid yields a similar compound boiling at 118°–122° C. Heated in sealed tubes at 100° both compounds yield cyanuric ether and free hydracid. The cyanic ether obtained by Cloëz by acting upon ethylate of sodium with chlorid of cyanogen, and which is a neutral liquid insoluble in water and not volatile, exhibits an entirely different behavior toward the hydracids. Chlorhydric acid converts it into cyanuric acid and chlorid of ethyl, the reaction being represented by the equation

$$3(C_2NO.C_4H_5O)+3HCl=C_6N_3O_3.3HO+3C_4H_5Cl.$$

Bromhydric acid acts in a similar manner. Gal is of opinion that the compound of Cloëz is the true cyanate of ethyl, $\left.\begin{matrix}C_4H_5\\C_2N\end{matrix}\right\}O_2$, while the cyanic ether of Wurtz is an ammonia, $N\left\{\begin{matrix}C_2O_2\\C_4H_5\end{matrix}\right.$. The author promises a further investigation of the subject. The connection of his results with those of L. Henry, mentioned above, will be obvious at a glance.—*Bull. de la Soc. Chim.*, Dec. 1866, p. 435. W. G.

7. *On the action of alcohols upon terchlorid of phosphorus.*—When absolute alcohol is poured drop by drop into an equivalent quantity of terchlorid of phosphorus a powerful reaction ensues, the principal product of which is a body having the formula $P(\text{Є}_2H_5\Theta)Cl_2$, or oxethylchlorid of phosphorus. This is a liquid boiling at 117° C., heavier than water, and decomposed by this into alcohol and phosphorous acid. Butylic and amylic alcohols give analogous bodies.—*Bull. de la Soc. Chim.*, Dec. 1866, p. 481. W. G.

8. *On the polymers of acetylene.*—Berthelot has studied the products of the action of heat upon acetylene, and has arrived at results of great interest and importance. When acetylene is heated to a temperature approaching that at which glass melts, it is gradually converted into a series of polymeric bodies, among which are benzol, styrol, reten, and fluorescing hydrocarbons. In one experiment Berthelot prepared pure acetylene by the direct combination of pure hydrogen and pure carbon, and then obtained from this acetylene benzol, which was thus formed by actual synthesis from its elements. The relation between the two substances is readily seen since $3C_4H_2=C_{12}H_6$; benzol is therefore triacetylene. Berthelot believes that a volatile hydrocarbon occurring among the products of the action of heat upon acetylene is diacetylene, $2C_4H_2=C_8H_4$. Styrol or tetracetylene, $4C_4H_2=C_{16}H_8$, forming about one-fifth of the entire product was easily recognized. Naphthalin forms another product, and probably is a product of the decomposition of pentacetylene, $C_{20}H_8=5C_4H_2-H_2$. The highest product yet examined is retene, which Berthelot regards as enneacetylene, $C_{36}H_{18}=9C_4H_2$.—*Ann. der Chem. und Pharm.*, cxli, 173. W. G.

9. *New method for the preparation of oxygen.*—When cuprous chlorid $\text{Є}u_2Cl_2$ is exposed to the air, it absorbs oxygen and is converted into cuprous oxy-dichlorid $\text{Є}u_2\Theta Cl_2$. If this latter compound be heated to

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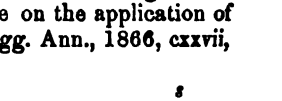
about 400° C., it is decomposed into oxygen and cuprous chlorid, as before.

Upon this reaction Mallet founds a method for the commercial preparation of oxygen. The cuprous salt, mixed with sand or clay to prevent fusion, is placed in a retort, which can be rotated horizontally. It is readily oxydized by a current of air, passed over it for three or four hours. The heat necessary for the decomposition is no higher than that required for the preparation of oxygen from potassic chlorate. With this arrangement the loss of material is inappreciable. Each kilogram of cuprous chlorid yields 28 to 30 liters of oxygen.

A very simple modification of this method permits the preparation of chlorine gas with equal facility. If after oxydation chlorhydric acid gas be conducted over the cuprous oxy-dichlorid, the latter becomes cupric chlorid, $CuCl_2$. At a red heat, this salt decomposes into cuprous chlorid and chlorine.—*L'Institut*, 1867, p. 61.

10. *Apparatus for detecting differences of density in transparent media.*—Dr. A. Töpler has given a new method of observing certain important phenomena which escape attention by direct vision more or less completely. His pamphlet, "Beobachtungen nach einer neuen optischen Methode, Bonn, 1864," is not at hand; but from a very complete synopsis (with quarto plate) in Ergänzungsblätter zür Kenntniss der Gegenwart, Hildburghausen, 1866, i, 88, and from his article on the application of this method to microscopic observations, in Pogg. Ann., 1866, cxxvii, 556–580, we give the following:



Let A be a radiant; a good lamp surrounded with a brass cylinder. The latter has a circular opening, in front of which is placed a small vertical metallic screen with holes near its edge for the transmission of the light from A. This pencil of light falls upon a system of lenses, L, of at least two and a half to four feet focal length and of large diameter. The lenses, L, in the usual tube, together with the lamp, A, and screen, are supported on the same table; the screen can be moved in the axis of the lens, L, to change the divergence of the pencil. At a distance of from ten to twenty-five feet, L will give the image B of A. Here a small astronomical telescope, T, is so placed in the common axis that this image falls just on the front face of the objective; at this point is placed a metallic screen, *s*, having a straight, sharp edge; this screen can be moved by a screw, like the movable part in the slide of Bunsen's spectroscope. This is the "Schlieren"-apparatus, which hence may be put together in almost any philosophical cabinet.

If the lens, L, is perfect, the entire beam of light is concentrated in B; and in moving the screen, *s*, down, no change in the image, B, is observed until the screen reaches B, when the lens, L, *suddenly* disappears. But if L is not perfect, if it contains a flaw, *f* (i. e., *Schliere*), then this will refract light differently from the body of the lens; the rays from *f* will *not* collect in B; when *s* has nearly reached B, many of the rays from *f* (which otherwise would have reached the objective of T and thus the eye) are now cut off; hence *f appears dark on the bright ground* of the image of L. And when *s* is moved down so as completely to cut off the regular image B, many of the rays from *f* will yet reach the ob-

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jective, so that *f now appears bright upon a dark ground.* As the distance LT is quite considerable (even twenty feet or more), and as the telescope may have considerable power, this method is *incredibly sensitive.* The object to be examined must of course be transparent; if it is the objective of a telescope, this serves as L; if a flame or the like, it is placed at M near L, between L and T.

Töpler has found that perfectly homogeneous glass is exceedingly rare; it has usually either filiform flaws (which are easily detected and but little injurious) or has flaws throughout its entire mass, appearing in this apparatus as if brushed over by a brush. These very injurious flaws hitherto were not discovered till the lens was almost worked out; by this apparatus they are easily detected in the glass.

The *flame* of a Bunsen burner (placed at M) shows besides the three well known parts visible to the unaided eye, two others: an exterior, large, very well defined cone (consisting of the heated products of combustion and of air) and a bright interior cone, resting on the tube as the base, having a sharp outline (consisting of the gas mixture before any combustion has taken place).

The *electric spark,* when produced by the induction coil and allowed to pass between the electrodes held at M, shows very interesting and instructive phenomena; of which, however, it would be very difficult to give a clear idea in a few words.

The *sound-wave in air* corresponding to each separate spark is, like the sound, a *single impulse;* it is beautifully visible as a *bright circle or ellipse* around the source of sound, moving regularly from the center outward. A succession of sparks in regular intervals gives moving circles of light. The spark from a Leyden jar gives a sharp sound, and one increasing circle of light one sound-wave. That this is a sound-wave, Töpler proved by trying in vain to blow it aside by a feeble current of air, and also by finding it to progress more rapidly in heated air. But more interesting yet is his experiment on the reflected sound-wave. Suspending a glass plate from the brass electrodes by means of corks, he saw in lines of light precisely the same phenomenon which we observed when circular waves of a liquid meet a plane wall: they are reflected as circles described from a point as far behind the obstacle as the origin of the wave is in front of the same. By having the electrodes either in the axis of the apparatus or at right angles to it, Töpler found that in the first case the lines were elliptical, in the latter circular: so that the wave is a surface of revolution around the electrodes as an axis.

It may well be said that by means of Töpler's apparatus we *see the sound;* in Chladni's and even in Kundt's experiments we only see the motion imparted by air to some other body, not the motion of the air itself. For the application of this method to the microscope, see Töpler's article in Pogg. Ann. G. H.

11. *On atomic heat and the specific gravity of gases.*—GUSTAV SCHMIDT, known by his theoretical labors on heat and the steam-engine,* has published an article on "*Atom-wärme*" (the specific heat of atoms, which we abbreviate as above); but only the appendix to the article, treating on the specific gravity of gases, seems to contain any addition to our knowledge.

* Theorie der Dampfmaschinen. Freiberg, 1861.

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The atomic heat, w, of an element ($=gc$, where g is the atomic weight and c the specific heat of the substance), he endeavors to prove to be $w=an$, where a is a constant, the same for all the elements, and n the characteristic of the element. Therefore, if α represents the number of atoms in any compound, and if the atomic heat of the compound equals the *sum* of the atomic heat of the several atoms, it follows that

$$w=gc=\Sigma\alpha\,.\,an=a\Sigma\alpha n.$$

Schmidt makes a number of suppositions in regard to a and hence obtains different values of n. For *solids* he takes either $a=\frac{32}{30}=1{\cdot}0666$ or $a=0{\cdot}8$; for gases he adopts $a=0{\cdot}86$, and correspondingly for n.

	Solids.		Gases.
n	$a=1{\cdot}0666$	$a=0{\cdot}8$	$a=0{\cdot}86$
2	H, C, B, Si	C	H
3	P	H, B, Si	
4	F, O	.....	O, C, N, S
5	N, S	O, P	Br, Cl
6	Cl, Br, I, and metals	F	P, Si
7		N, S	
8		Cl, Br, I, and metals	As, Sn, Ti

A glance at this table is enough to convince any one that this supposition cannot be correct. We need only to calculate the values $w=an$ from this table, and compare them with those used by Kopp, to see that the so-called "*characteristic*" is essentially characterized by having no character whatever.

We should not have referred to this memoir if we had not found the closing pages thereof to contain a most accurate theoretical determination of the *specific gravity* δ of all permanent gases, and of vapors above their boiling points (that of atmospheric air $=1$). If g be the *weight of a molecule* of equal volume with HCl or NH_4, he finds $\delta=0{\cdot}0346832\,g$, with a possible error in the coëfficient of less than one-fifth per cent, and *an actual error of less than one-fiftieth per cent.* To find this very important number he makes use of a relation from the mechanical theory of heat and the following quantities from experiments: pressure of atmosphere, specific gravity of air, coëfficient of expansion of air, and the percentage composition of the atmosphere with $O_2=32$ and $N_2=28$: all fundamental quantities determined by Regnault and others with most scrupulous care; by adopting the specific gravity of oxygen as determined by Regnault (1·10563) the atmosphere would contain 23·57 instead of 20·81 per cent of oxygen. This shows that the calculated density of oxygen (1·1099) is much more reliable than the observed one.

He finds furthermore, the *mechanical equivalent of heat* $k=422{\cdot}06$ meterkilograms (for kilogram-Centigrade) instead of Joule's, 423·54, $A=\frac{1}{k}$; the specific heat of aqueous vapor $=H_2\Theta$ 0·3822. As a further consequence from an empirical relation, $g(C'-C)=2$, (where C' specific heat by constant pressure, C rational specific heat) he finds finally the Gay-Lussac Mariotte's law expressible in $\frac{ApV}{T}=2$; or, *by heating a*

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molecule of volume, V, *of any gas under any constant pressure*, *p*, *at any temperature*, T ($T_0 = \frac{1}{\alpha} = 273°$ C. below 0° C.) *two calorics* (or units of heat) *are necessary to overcome the external work for each degree C. the temperature is raised.* The molecular weight and the unit of heat must of course refer to the same unit of weight.—*Sitzungsberichte*, Wien, 1865, lii, 417–452; *Corresp. Blatt d. naturf. Vereins*, Riga, 1864, xiv, 35–44; *L'Institut*, 1866, p. 191. G. H.

12. *Expansion of water below* 4° *C.*—Dr. Weidner has, by means of water thermometers (bulb a cylinder 11mm. diameter, 100mm. high, tube not less than 1mm.), determined this expansion with great care, starting in four independent series, with four different water-thermometers from the temperature of 4° C. to 0° C. and then to −9° or −10° C. From each series he calculates by a formula of form $V = 1 + at + bt^2 + ct^3$ the expansion for each degree C., the volume at +4° C. being unity.

By comparing the four series I find a very close correspondence except for −4° C., where the first series deviates 37 millionths; on referring to the formula, the stated value, 513 millionths, is found to be 550·6, agreeing with the other three in the sixth decimal. Taking the mean from the four values given by Weidner we obtain the following volumes of water.

	Weidner.	Despretz.	Pierre.
+ 4° C.	1·000000	1·000000	1·000000
+ 3 "	14	8	5
+ 2 "	40	33	27
+ 1 "	80	73	63
0 "	137	127	118
− 1 "	210	214	214
− 2 "	302	308	317
− 3 "	415	422	430
− 4 "	550	562	556
− 5 "	709	699	700
− 6 "	893	918	865
− 7 "	1104	1135	1054
− 8 "	1344	1373	1271
− 9 "	1608	1631	1520
−10 "	1·001905		1803

Above zero Weidner's volumes are greater; but between 0° and −6° C. the three experimenters correspond well enough.—*Pogg. Ann.*, 1866, xxix, 300–308. G. H.

13. *Specific heat of soils.*—L. Pfaundler has determined the specific heat of seventeen soils with great care. The accuracy of the method with a modified Regnault's apparatus, was proved by determining the specific heat of water and of *Iceland spar*. The first showed the same increase as found by Regnault; the second gave, by ten independent determinations on the same piece, successively more and more subdivided, 0·20588, with a probable error of only 0·00006. This agrees with Regnault's results, 0·20694 (from eighteen determinations), and Kopp's, 0·206 (from four determinations), thus disproving that of Pape and Neumann (0·202). For *soils* he finds the specific heat between *one-fifth* and *one-half* (0·1923 and 0·5069); the most common value is 0·25 to 0·30.

Soils free from humus have the lowest specific heat, whether they con-

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sist of sand or lime; this might have been concluded from the fact that calcite and quartz have almost the same specific heat, viz., 0·20 and 0·19. The more rich a soil in humus, the higher is its specific heat. Thus peat was found to have 0·507, and a soil, very rich in humus, from Kaiserstein, gave 0·4143. Since water also must increase the specific heat of a soil, we may conclude that loamy soils also have a high specific heat.

So great a variation in so important a physical property of soils is of considerable importance to agriculture. A plant sensitive to changes in temperature may be unable to grow on soils of low specific heat, however excellent this soil might be in other respects.—*Pogg. Ann.*, 1866, cxxix, 102–135. G. H.

14. *The spectrum of the electrical brush and glow* has been observed by A. SCHIMKOW. While the spectrum of the spark is affected by and produced in both nitrogen and oxygen, the *brush* discharge only gives *nitrogen* lines, and is not formed at all in pure oxygen; a trace of nitrogen entering the tube is sufficient to reproduce the light and its peculiar lines. The same is true in regard to the luminous glow observed when electricity is discharged between two points. At the same time the latter spectrum is still much fainter than that of the brush. It is characteristic of these lines that they especially occur in the most refrangible part of the spectrum. This seems due to the *much lower temperature* in the brush and glow discharge, as compared to the discharge in a spark. By introducing in the circuit of a coil a wet string four meters long, Schimkow made the nitrogen spectrum of a Geissler-tube appear precisely like the brush spectrum: the yellow lines had been weakened much more than the violet ones; at a low temperature, therefore, nitrogen seems especially to emit the most refrangible rays, harmonizing with the observation of von Waltenhofen, according to which the least refrangible rays are first extinguished when air is successively more and more rarefied. Thus the *brush* and *glow* are due to the luminosity of nitrogen at a temperature below that at which oxygen becomes luminous; and furthermore they consist principally of the more refrangible rays.—*Pogg. Ann.*, 1866, cxxix, 508–520; *L'Institut*, 1867, p. 55. G. H.

II. MINERALOGY AND GEOLOGY.

1. *Note on a new genus of fossil Crustacea;* by F. B. MEEK.—In the last number of this Journal, p. 257, I mentioned having seen in "The Reader," a notice of a paper by Mr. Henry Woodward, read before the Geological Society of London, in which he proposed to establish a new genus *Prestwichia*, for the reception of some of the species generally referred to *Belinurus*, but differing from the types of that genus in having the body segments anchylosed. The abstract of Mr. Woodward's paper, mentioned by me, was unaccompanied by figures or diagnosis, and no particular species were cited, but the fact that our Illinois fossil has its body segments anchylosed, and agrees very nearly in its general appearance with a part of the species referred by English authors to *Belinurus*, led me to refer it to the new genus *Prestwichia*. Since that time, I have seen Mr. Woodward's interesting paper as published in the Quarterly Journal of the Geological Society, vol. xxiii, No. 89, p. 28, with ex-

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cellent figures, both of the typical *Belinurus* and the new genus *Prestwichia*. From these figures and the accompanying remarks, it becomes evident that certain differences between the previously published figures of the type upon which the genus *Prestwichia* is founded and our Illinois fossil, and which were noticed by us in the remarks accompanying the description of the Illinois species as being probably of more than specific importance, if not due to some accidental imperfection of the specimens figured by Prestwich, really exist, and consequently forbid the reference of our species to this new genus. As it also differs upon quite as important characters from the genus *Belinurus*, as now restricted and clearly illustrated by Mr. Woodward, it becomes necessary to propose for its reception a third genus, holding a somewhat intermediate position between *Belinurus* and *Prestwichia*.

For this new genus I would propose the name *Euproops*, in allusion to the anterior position of its eyes. This form is at once distinguished from the restricted genus *Belinurus*, by its anchylosed abdominal segments, and the anterior position of its eyes, as well as by the more oval or subcircular outline of its abdomen. From *Prestwichia*, with which it more nearly agrees in general form, as well as in its anchylosed segments, it differs remarkably in having the area enclosed by its eye-ridge (glabella) comparatively small, and of a quadrangular form, with the eyes situated far forward at its anterior lateral angles. On comparing these characters of the central region of its head with the corresponding parts of *Prestwichia*, as illustrated by Mr. Woodward, it will be seen that the latter differs in having the glabella proportionately much larger, and transversely elliptic in outline, with the eyes widely separated and placed far back at its lateral extremities. It also has within this large elliptic area a smaller crown-shaped one not seen in *Euproops*, but corresponding in size and general appearance with that bearing the eyes at its anterior lateral angles in the latter type.

March 29th, 1867.

2. *Geological Survey of Illinois*, A. H. Worthen, Director. Volume II, *Paleontology*, xix, and 470 pp., royal 8vo, with 50 plates and 30 wood-cuts. Springfield, 1866. Published by authority of the Legislature of Illinois.—This important and beautifully illustrated work, consists, besides the Introduction, of three Sections, as follows:

Section I.—"Descriptions of new species of Vertebrates, mainly from the Subcarboniferous limestones and Coal Measures. By J. S. Newberry and A. H. Worthen.

"Remarks on the occurrence of Fossil Fishes in Illinois. By A. H. Worthen.

"Supplement to descriptions of Vertebrates, consisting of a description of a new genus, and species of Reptiles from the Coal-measures. By Prof. Edw. D. Cope.

Section II.—"Descriptions of Invertebrates from the Carboniferous system. By F. B. Meek and A. H. Worthen.

"Supplement to the descriptions of Invertebrates, consisting of the descriptions of Polyzoa from the Paleozoic rocks. By H. A. Prout, M.D.

Section III.—"Report on the Fossil Plants of Illinois. By Leo Lesquereux."

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From the Introduction we learn that:

"The number of species of all kinds, illustrated and described, in the Report, is about 325, of which nearly 300 were discovered or first made known to science through the agency of the Illinois Geological Survey. Of these 325 species, 50 are plants, 156 invertebrate animals, and 119 vertebrates. Altogether they represent 115 genera, 25 of which have been established by parties connected with the survey. Of these genera 18 are plants, 67 invertebrates, and 30 vertebrates—the latter of which, with one exception (a *Batrachian*), being all fishes. Of the 115 genera represented, 81 are more or less fully characterized, and most of them illustrated in this volume."

From the cursory examination we have been enabled to make, we find many important additions to our knowledge of American Paleontology in this volume. At present we can only notice a few of them.

Mr. Worthen states that the fossil fishes abound in four horizons—usually limited to a single stratum, rarely more than a few inches in thickness. In the beds which form the base of the Carboniferous system in Illinois, these remains are comparatively rare; but in the upper strata they become exceedingly abundant. The lowest bed occurs in the upper part of the Burlington limestone. It is a stratum of brownish-gray rock, from four to six inches thick, in which the teeth and spines of fishes are imbedded in great numbers. It was first observed at Quincy, Illinois, but was afterwards identified on Honey creek in Henderson county and at Augusta in Iowa, nearly one hundred miles away from the first named locality. The second *fish bed* occurs fifty or sixty feet higher, in the series near the base of the quarry rock of the Keokuk group. The third, in ascending order, is found in the upper part of the Keokuk limestone. The fourth is situated at the junction of the lower limestone in the Chester group with the green shales above. All these beds belong to the Mountain limestone or Subcarboniferous period. In the Coal-measures, the remains of fishes again become more rare, in Illinois. "Of the 118 species, described and illustrated in this volume, 16 are from the Coal-measures, 17 from the Chester limestone, 18 from the St. Louis limestone, 49 from the Keokuk limestone, 14 from the Burlington limestone; 3 from the Kinderhook group, and 1 from Devonian Strata," (p. 16). This is the first memoir in which any large number of the paleozoic fishes of America have been described; and as the species are well figured it will constitute the foundation on which all subsequent investigations in this department must be conducted. Next follows an interesting description of a new fossil *Batrachian*, discovered by Mr. Joseph Even, near Morris, Grundy county, Illinois, in a bed near the base of the Coal-measures.

In Section II will be found a great deal of information bearing on the classification of the Crinoidea; especially as regards such genera as *Actinocrinus*, *Cyathocrinus* and *Poteriocrinus* the relations of which are here discussed at length. The new genus *Strotocrinus* (M. & W.) has the formula of *Actinocrinus* in the lower part of the body, but is distinguished by the remarkable structure of the upper portion, which is greatly expanded and forms a ten rayed horizontal disc, the plane of which is at right angles to the vertical axis. The interior of *S. regalis*,

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and some other species is provided with a peculiar, convoluted internal plate, resembling a shell of a *Bulla* or *Scophander*, placed with its longer axis so as to coincide with that of the body of the crinoid. This is illustrated by a wood-cut on p. 191.

The genus *Steganocrinus* has also the structure of *Actinocrinus* in the lower part, but with: "Rays, from the third primary radial pieces, forming greatly produced, free arm-like appendages, either bifurcating or simple, which are covered their entire length above by small plates, and provided on each side with a row of alternating true arms. Vault with a subcentral proboscis." These arm-like appendages are tubular, with the ambulacral orifices arranged along the sides,—opening out into the grooves of the true arms.

On page 220 there are some figures illustrating the wonderful structure of the vault of *Gilbertsocrinus*. It is there shown that this genus is identical with *Trematocrinus* (Hall), *Goniasteroidocrinus* (Lyon and Casseday), *Rhodocrinus* (Miller) pars, (as understood by some naturalists), and *Ollacrinus* (Cumberland). This latter name has priority over all others, but its author did not characterize the genus. The vault exhibits fine slender lobes, which are branched at their extremities. These have been mistaken lately for arms,* but M. and W. have shown that the true arms are situated in the re-entering angles between them. There are numerous important improvements in the classification of paleozoic genera of Echinodermata suggested in this work, which can only be understood by consulting the very instructive observations and figures.

An interesting fossil belonging to the *Xiphorura* is doubtfully placed in the genus *Bellinurus*, but Mr. Meek has informed us that he now considers it distinct from that genus and also from *Prestwichia* to which he afterwards thought it might be referable (this vol. ante, p. 257). As it will be noticed elsewhere in this Journal, we need not allude to it further here. We may be permitted, however, to remark on the affinities of the *Xiphorura* and the *Eurypterida* that the beautiful specimens of *Eurypterus* figured by Nieskowski in the "Archiv fur die Naturkunde Livland, &c.," 1859, have the six anterior segments of the body sculptured as in *Pterigotus;* but the posterior six are not so marked, unless indeed obscurely along the median line. These latter six have their posterior angles produced backward, to form short angular spines similar to those in the lateral margins of the abdomen of *Limulus*. If then we examine the inner surface of the cephalo-thorax of *Limulus*, we shall find there, indications of six or seven anchylosed segments, all with the scale-like sculpture of *Pterygotus*. These markings are not seen on the outside, and, though the character at first sight may not seem important, yet it will strongly impress many observers with the idea that we have buried, as it were, in the buckler of *Limulus* the anterior segments of *Eurypterus*. The species figured by Nieskowski is clearly not *E. remipes* as he supposes.

Mr. Lesquereux gives, p. 463, a table of the number of species of plants mentioned in his Report. The following are the general results:

* John Rofe, Esq., F.G.S., has figured (Geological Magazine, vol. ii. pl. 8) an English specimen with portions of these appendages which he maintains to be the remains of the arms. They are evidently, however, merely projecting lobes of the body, the formations of which are not yet understood.

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1. Whole number of species in Illinois, ... 120
2. Number of new species in Illinois, ... 37
3. Species found in Illinois not published before, ... 60
4. Species in the catalogue not found in Illinois, ... 219
5. Whole number in the catalogue, ... 280
6. New species in the same, ... 146

This Report was drawn up in 1860; since then, other species have been collected, which will be described in future publications of the Survey.

The two volumes of the Geology of Illinois, which have been issued, establish for at least one Scientific Institution of that noble State, a very high character. The Paleontology is a first class work, equal to the best that has been published by any geological survey, and where the fossils are well worked out in a country, we may be sure that the physical structure is also correctly understood.

The principle, that every nation should contribute something toward the general advancement of knowledge (not merely by the dissemination of what was previously known, but by assisting in the discovery of those truths which, although existing in nature, have remained unknown to man from the beginning), is now recognized by all enlightened communities to be a sound one. The people of the State of Illinois have made an effort in that direction which, under the wise management of their able State geologist, has been highly successful, and creditable to all the parties concerned. E. B.

3. *On the occurrence of Eozoon in the Primary Rocks of Eastern Bavaria;* by Prof. GUMBEL. (Ber. Ak. München, 1866; Q. J. Geol. Soc., xxii, 23.)—A new species of *Eozoon*, the *Eozoon Bavaricum*, has been discovered by Prof. Gümbel in a rock consisting of a granular aggregation of calcite, serpentine, and a white hornblendic mineral, supposed to be of Huronian or Cambrian age. The specimens examined were from near Wunseidel and Thiersheim, and between Hohenberg and the Steinberg, especially the last-named locality. It exhibits—(1.) A thin band almost entirely calcareous, and traversed by a network of straight lines, or, when treated with acid, divided by band-like ribs into irregular cell-like spaces, the calcite filling which is seen to be granular. (2.) Thicker calcareous portions abounding in tufts of fine tubes, exactly as in *Eozoon;* these tubes end at the serpentinous portions (3.), which have generally the same form as in the *Eozoon* from Steinhag before described, but are much smaller. In decalcified examples they may be seen to possess the same vaulted margins as *Eozoon;* their breadth averages ·1 mm. and the diameter of the tubes ·01 mm. Generally these serpentine bands pass into an adjoining portion (4.), of one-half the width, or less, made up of very much twisted lamellæ, consisting of serpentine or a whitish mineral, and possessing highly vaulted and deeply channelled outlines. Prof. Gümbel considers that on the whole these characters undoubtedly prove the affinity of this more recent and very much smaller form to the group *Eozoon;* but as the last-mentioned structure (4.) differs from what has been observed in *Eozoon Canadense*, he gives it the distinctive name of *Eozoon Bavaricum*. Prof. Gümbell makes out, with more or less probability, that the *Eozoon* occurs in the pargasite of Pargas, Finland, the Coccolite-limestone of New York, at Tunaberg, Boden in Saxony, and Hodrisch in Hungary.

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4. *A Catalogue of Official Reports upon Geological Surveys of the United States and British Provinces.*—In arranging a set of American Geological Reports in the Library of Yale College, the following catalogue became necessary; and it is here published in the hope that it may be of service to geologists.[1]

PART II.—STATES AND TERRITORIES WEST OF THE MISSISSIPPI RIVER AND BRITISH PROVINCES.

MINNESOTA.

1866. *Henry H. Eames*, 1st Ann. Rep., Saint Paul, 8vo, 23 pp.
" *Charles Whittlesey*, Rep. on Mineral Regions, Cleveland, 8vo, 54 pp.

IOWA.

1858. *J. Hall* and *J. D. Whitney*, Final Rep., vol. I, Albany, 8vo, 724 pp., 29 pl., 2 sect., map.
1859. *J. Hall* and *J. D. Whitney*, Suppl., vol. I, Albany, 8vo, 4 pp.
1860. " " " 8vo, 94 pp., 3 plates.
1860. " " Ann. Rep., Des Moines, 8vo, 75 pp.
1861.* *J. Hall*, Prelim. Notice of New Crinoidea, Albany, 8vo, 18 pp.
1867. *C. A. White*, 1st Ann. Rep., Des Moines, 8vo, 4 pp.

IOWA, WISCONSIN AND ILLINOIS.

1844. *D. D. Owen*, Rep. to Treas. Dept., Washington, 8vo, 191 pp., 16 pl., 4 maps.

WISCONSIN AND IOWA.

1848. *D. D. Owen*, Rep. on Chippewa Land Dist., Washington, 8vo, 134 pp., 23 pl., 14 sect., maps.

WISCONSIN, IOWA AND MINNESOTA.

1852. *D. D. Owen*, Final Rep. (U. S.), Philadelphia, 4to, 638 pp., 27 pl., 16 sect., map.

MISSOURI.

1855. *G. C. Swallow*, 1st and 2d Ann. Rep., Jefferson City, 8vo, 207, and 238 pp., 32 pl., 5 maps.
1857.* *G. C. Swallow*, 3d Ann. Rep., —— "
1859.* " 4th " " Jefferson City, 8vo, 14 pp.
1861.* " 5th " " " " " "
" " Geol. Rep. on S. W. Branch Pacific R. R., St. Louis, 8vo, 93 pp., map.

KANSAS.

1866. *Benj. F. Mudge*, 1st Ann. Rep., Lawrence, 8vo, 56 pp.
" *G. C. Swallow*, Prelim. Rep, Lawrence, 8vo, 198 pp.

ARKANSAS.

1858. *D. D. Owen*, 1st Rep., Little Rock, 8vo, 256 pp.
1860. " 2d " Philadelphia, 8vo, 433 pp.

[1] Of those Reports marked with an * one copy is needed at the Library of Yale College; and also one copy of any Report not included in the list: persons having them to dispose of are requested to notify the Librarian.

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LOUISIANA.

1853. *Randolph B. Marcy*, Rep. to War Dept. on Red River of La., (Geology by E. Hitchcock and G. G. Shumard; Paleontology, by B. F. Shumard,) 8vo, 320 pp., 66 sect. and plates.

TEXAS.

1859. *B. F. Shumard*, 1st Ann. Rep., Austin, 12mo, 17 pp.

ROCKY MOUNTAIN REGION.

1809. *M. Lewis* and *W. Clark*, Expedition across American Continent in 1804–6, by order United States Government, Philadelphia, 8vo, 2 vols. (London, 4to, 1814, and 8vo, 3 vols. 1817), maps.

1810.* *Z. M. Pike*, Expedition in western Territories in 1805–7, by order U. S. Government, Philadelphia, 8vo, maps, (London, 4to, 1811).

1823.* *Stephen H. Long*, Expedition from Pittsburg to Rocky Mts., in 1819–20, (War Dept.) (Compiled by Edwin James,) Philadelphia, 8vo, 2 vols. 503, and 442 pp. Atlas, (London, 8vo, 3 vols. 1823).

1824.* *S. H. Long*, Exped. to source of St. Peters River, in 1823, (War Dept.) (Geology by Wm. H. Keating,) Philadelphia, 8vo, 2 vols., maps, (London, 8vo, 2 vols. 1825).

1835. *G. W. Featherstonhaugh*, Rep. on Elevated Country between Missouri and Red Rivers, Washington, 12mo, 97 pp.

1836. *G. W. Featherstonhaugh*, Rep. on Geol. Reconn., *via* Wisconsin, to Coteau de Prairie, Washington, 12mo, 168 pp.

1843. *I. N. Nicollet*, Rep. to illustrate Map of Hydrographical Basin of Mississippi River, Washington, 8vo, 170 pp.

1845. *John C. Fremont*, Exped. to Rocky Mts. in 1852–4, (War Dept.), (Paleontology by James Hall), Washington, 8vo, 693 pp.

1848. *W. H. Emory*, Exped. from Fort Leavenworth to California, (War Dept.), includes Reports of J. W. Albert, P. S. Cooke, and A. R. Johnson, (Paleontology by J. W. Bailey), Washington, 8vo, 614 pp., maps.

" *A. Wislizenus*, Rep. of tour to North Mexico in 1846–7, with Col. Doniphan's Expd., Washington, 8vo, 141 pp., maps.

1852. *Howard Stansbury*, Exped. to Great Salt Lake, (War Dept.), (Geology and Paleontology by James Hall,) Washington and Philadelphia, 8vo, 487 pp., maps.

1853. *L. Sitgreaves*, Exped. down Zuni and Colorado Rivers, (War Dept.), Washington, 8vo.

1856. *G. K. Warren*, Exped. to Rocky Mts. in 1855, (Geology by F. V. Hayden), Washington, 8vo.

1857. *W. H. Emory*, Rep. on U. S. and Mexican Boundary Survey, vol. I, (Geology by C. C. Parry, A. Schott, W. H. Emory, and James Hall; Paleontology by James Hall and T. A. Conrad), Washington, 4to, 21 plates.

1859. *W. H. Emory*, Rep. on U. S. and Mex. Boundary, vol. II, Botany and Zoology; no Geology, Washington, 4to, plates.

1855. *Rep. on Pacific Railroad Exploration*, (War Dept.), vol. I, (Geology by George Gibbs), Washington, 4to.

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1855. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. II, (Geology by James Schiel and Wm. P. Blake; Paleontology by J. Schiel J. W. Bailey, and W. P. Blake), Washington, 4to, plates.

1856. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. III, (Geology, by W. P. Blake, and Jules Marcou; Paleontology by James Hall,) Washington, 4to, plates.

" *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. IV, Botany; no Geology, Washington, 4to, plates.

" *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. V, (Geology by W. P. Blake; Paleontology by L. Agassiz, T. A. Conrad, J. W. Bailey, and Geo. C. Schäffer,) Washington, 4to, plates.

1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VI, (Geology by J. S. Newberry; Paleontology by T. A. Conrad), Washington, 4to, plates.

1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VII, (Geology by Thos. Antisell; Paleontology by T. A. Conrad), Washington, 4to, plates.

1857. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. VIII, Zoology; no Geology, Washington, 4to, plates.

1858. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. IX, Zoology; no Geology, Washington, 4to, plates.

1859. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. X, Zoology; no Geology, Washington, 4to, plates.

1855. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. XI, Literature of Surveys, and maps; no Geology, Washington, 4to.

1860. *Rep. on Pacific R. R. Explor.*, (War Dept.), vol. XII, Parts I and II, Botany and Zoology; no Geology, Washington, 4to, plates.

1862. *F. V. Hayden*, Rep. on Geology of Upper Missouri Region, Philadelphia, 4to, 218 pp., map.

1865. *F. B. Meek* and *F. V. Hayden*, Rep. on Paleontology of the Upper Missouri, Part I, (Smithsonian Cont.) Washington, 4to, 135 pp., 5 plates.

PACIFIC COAST REGION.

Oregon and Northern California.

1848. *J. C. Fremont*, Rep. upon Upper California, Washington, 8vo.

1850. *James D. Dana*, Rep. on Geology of U. S. Explor. Exped., in 1838–42, New York, 4to. Atlas.

1850. *P. T. Tyson* and others, Reps. to War Dept., Washington, 8vo, 128 and 37 pp., 12 maps and sections.

1854. *Wm. P. Blake*, Rep. to War Dept., Washington, 8vo, 80 pp.

California.

1853. *John B. Trask*, 1st Ann. Rep. Geol. Sierra Nevada, ——?, 8vo, 31 pp.

1854. *J. B. Trask*, 2d Ann. Rep. Geol. Coast Mts. and part of S. Nevada, ——?, 8vo, 95 pp.

1855. *J. B. Trask*, 3d Ann. Rep. Geol. Coast Mts., Sacramento, 8vo, 93 pp.

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1856. *J. B. Trask*, 4th Ann. Rep. Northern and Southern Cal., Sacramento, 8vo, 66 pp.

1855. *W. P. Blake*, Rep. to Coast Survey on Geology of Cal., Washington, 22 pp., 4to.

1861. *Josiah D. Whitney*, Address to Legislat., on Survey, San Francisco, 12mo, 50 pp.

1862. *J. D. Whitney*, Letter to Governor (Rep. of Progress), San Francisco, 8vo, 7 pp.

1862.* *J. D. Whitney*, Address to Legislat., on Survey, San Francisco, 12mo, 33 pp.

1863. *J. D. Whitney*, 2nd Ann. Rep., San Francisco, 8vo, 12 pp.

1864. *J. D. Whitney*, Rep. Paleontology, vol. I, Philadelphia, 8vo, 243 pp., 32 pl. (Carboniferous and Jurassic Fossils by F. B. Meek; Triassic and Cretaceous, by W. M. Gabb.)

1865. *J. D. Whitney*, Rep. Geology, vol. I, Philadelphia, 8vo, 498 pp., 10 plates.

1866. *J. D. Whitney*, Rep. Paleontology, vol. II, part I, Philadelphia, 8vo, 38 pp. (Tertiary Invertebrate Fossils by W. M. Gabb.)

1866. *J. D. Whitney*, Letter to Governor on Survey, San Francisco, 8vo, 14 pp.

California and Arizona.

1861. *Joseph C. Ives*, Rep. on Colorado River, Washington, 4to, plates, (Geology and Paleontology by J. S. Newberry.)

BRITISH PROVINCES.

Newfoundland.

1839.* *J. B. Jukes*, Prelim. Rep. (Legislative Doc.), folio, St. Johns.

1842.* " General Rep. in Author's "Excursions in and about Newfoundland," London, 12mo, 2 vols. (Separate, with sections, London, 12mo, 160 pp. 1843.)

Nova Scotia.

1846.* *J. W. Dawson*, Rep. on Coal-fields of Caribou Cove, &c. (Legis. Doc.) Halifax, folio.

1860. *Joseph Howe, and Henry How*, Rep. on Discovery of Gold in Nova Scotia, (Legis. Doc.) Halifax, folio, 4 pp.

1861. *J. Howe*, Rep. on Gold-fields. (Legis. Doc.) Halifax, folio, 7 pp.

1862. *Henry Poole*, Rep. on Gold-fields, Western Section. (Appendix on Minerals, by H. How.) (Legis. Doc.) Halifax, folio, 25 pp.

1862. *J. Campbell*, Rep. on Gold-fields, Eastern Section. (Legis. Doc.) Halifax, folio, 8 pp.

1863. *J. Campbell*, Rep. on Gold-fields. (Legis. Doc.) Halifax, folio, 12 pp.

1864* *David Honeyman*, Rep. on Geol. Survey of Nova Scotia, and Cape Breton. (Appendix on Minerals by H. How.) (Legis. Doc.) Halifax, folio, 7 pp.

1865. *H. How*, Rep. on Minerals collected by D. Honeyman. (Legis. Doc.) Halifax, folio, 4 pp.

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NEW BRUNSWICK.

1839. *Abraham Gesner*, 1st Ann. Rep., St. John, 8vo, 87 pp.
1840.* " " 2d " " " ——
1841.* " " 3d " " " 88 pp.
1842. " " 4th " " " 101 pp.
1843. " " Rep., with account of Public Lands, St. John, 8vo.
1850.* *J. Robb*, in Johnston's Agricultural Rep., Frederickton, 8vo, map.
1865. *L. W. Bailey*, Rep. on Southern N. Br., Frederickton, 8vo, 159 pp., map, section.
" *Henry Y. Hind*, Rep., especially on the Quebec Group, Frederickton, 8vo, 293 pp.

CANADA.

1845. *Wm. E. Logan*, 1st Rep. (for 1843), Montreal, 12mo, 159 pp.
1846.* " Rep. (for 1844,) " " 110 pp.
1847.* " " (for 1845), " " 125 pp.
" * " " (for 1846), " " 66 pp.
" * " 2 Repts. on Mining Region of Lake Superior, Montreal, 12mo, 31 pp.
1849.* *W. E. Logan*, Rep. (for 1847), Montreal? 12mo, 165 pp.
1849.* " Rep. on N. shore Lake Huron, Montreal, 12mo, 51 pp.
1850. " Rep. Progress for 1848, Toronto, 12mo, 65 pp.
" " " " 1849, " " 115 pp.
1852. " " " 1850, Quebec, " 54 pp.
" " " " 1851, " " 131 pp.
1854. " " " 1852, " " 179 pp.
1857. " " " 1853–6, Toronto, 12mo, 494 pp. Atlas, 4to, 22 pl.
1858. *W. E. Logan*, Rep. Progress for 1857, Toronto, 12mo, 240 pp.
1859. " " " 1858, Montreal, " 263 pp.
1863. " General Report, from 1843 to 1863, Montreal, 8vo, xxvii and 983 pp. Atlas.
1858. *E. Billings, J. W. Salter* and *T. R. Jones*, Decade III, Cystideæ, Asterideæ and Entomostraca, Montreal, 8vo, 102 pp., 11 pl.
1859. *J. W. Salter*, Decade I, L. Silurian fossils, Montreal, 8vo, 47 pp., 10 pl.
" *E. Billings*, Decade IV, L. Silurian Crinoideæ, Montreal, 8vo, 72 pp., 10 pl.
1865. *Jas. Hall*, Decade II, Graptolites of Quebec Group, Montreal, 8vo, 151 pp., 23 pl.
1865. *E. Billings*, Paleozoic fossils of Canada, Montreal, 8vo, 426 pp.
1866. " Catalogue Silurian Fossils of Anticosti, Montreal, 8vo, 93 pp.
1866. *W. E. Logan*, Rep. Progress from 1863 to 1866, Ottawa, 8vo, 322 pp.

BRITISH AMERICA.

1858. *Henry Y. Hind*, Rep. of Explor. between Lake Superior, and Red River, Toronto, 8vo, 425 pp., maps.
1860.* *H. Y. Hind*, Rep. on Assiniboine Exped. in 1858–9, Toronto, folio, maps.

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1863.* *H. Y. Hind*, Rep. of Explor. in Labrador, London, 8vo, 2 vols., maps.

1860. *Oscar M. Lieber*, Rep. on Geology of Labrador, (U. S. Coast Survey), Washington, 4to, 7 pp.

ARCTIC REGIONS.

1819. *John Ross*, Voyage to Baffins' Bay, &c. (Appendix, on Geology, by John McCulloch), London, 8vo.

1822. *John Franklin*, Exped. to Polar Sea, 1819–22. (Appendix on Geology by John Richardson), London, 4to.

1828.* *W. E. Parry*, 3d Voyage of Discovery in 1827. (Appendix on Geology by Robt. Jameson), London.

1828. *J. Franklin*, 2d Expd. to Polar Sea in 1825–7. (Appendix on Geology, by J. Richardson; Paleontology, by R. Jameson), London, 4to.

1835. *J. Ross*, 2nd Voyage of Discovery in 1829–33. (Geology by Author,) London, 4to, 2 vols.

1836.* *G. Bach*, Arctic Land Exped. in 1833–5. (Appendix on Geology, by W. H. Fitton), London, 8vo.

1839. *F. W. Beechey*, Exped. to Pacific and Behren Strait. (Appendix on Geology, by Wm. Buckland), London, 4to.

1852.* *P. C. Sutherland*, Journal of Voyage in Baffin's Bay, in 1850–51. (Appendix on Geology, by J. W. Salter), London, 8vo, 2 vols., plates.

1855. *E. Belcher*, Exped. to Arctic in 1852–4. (Appendix on Geology, by J. W. Salter), London, 8vo, 2 vols.

ADDITIONS AND CORRECTIONS TO PART I.

MAINE.

For the last three Reports on this State read as follows:—

1839. *Ezekiel Holmes*, Explor. and Survey of Aroostook River Territory, Augusta, 12mo, 78 pp.

1862. *E. Holmes* and *Chas. H. Hitchcock*, 1st Ann. Rep., Nat. Hist. and Geol., Augusta, 8vo, 387 pp.

1863. *E. Holmes* and *C. H. Hitchcock*, 2nd Ann. Rep., Nat. Hist. and Geol., Augusta, 8vo, 447 pp.

NORTH CAROLINA.

1867. *W. C. Kerr*, Rep. Progress of Survey, Raleigh, 8vo, 56 pp.

FLORIDA.

1851. *Louis Agassiz*, Rep. on Florida Coral-reefs, (U. S. Coast Survey), Washington, 8vo, 15 pp.

ILLINOIS.

1867. *A. H. Worthen*, Rep. Paleontology, vol. II, Springfield, large 8vo, 474 pp. 50 plates. (Vertebrates by J. S. Newberry and A. H. Worthen; Invertebrates by F. B. Meek and A. H. Worthen; and Plants by Leo Lesquereux.)

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5. *Note to Article on Kaolinite, etc.*, p. 361; by the authors.—When our article was just going to press, we received a letter from Prof. A. Knop, dated Carlsruhe, March 13th, directing our attention to his extremely interesting paper, *Beiträge zur Kenntniss der Steinkohlen-Formation und des Rothliegenden im erzgebirgischen Bassin*, *Neues Jahrbuch für Min.*, 1859, in which we find, p. 544, details of his investigation on the crystallography of the Schneckenstein "Kaolin." Prof. Knop has anticipated our observations on this substance in good part, as appears from the following quotation. "The crystals of the Kaolin from Schneckenstein have dimensions admitting of measurement under the microscope. They have an average length of about 0·021 mm., and a breadth of about 0·015 mm., and show, in part, the form of very sharply defined rhombic tables; in part, these are variously truncated on the angles connected by the macrodiagonal. Here and there the crystal-plates are aggregated to rhombic prisms and exhibit, on the assumption of rhombic crystallization, the combinations $\infty P . 0P$ and $\infty P . 0P . \infty \breve{P} \infty$. Repeated measurements gave constantly 118° for the obtuse angles of the planes."

The specimen from Schneckenstein kindly sent us by Prof. Knop, who first brought it to Wöhler's notice, perfectly resembles that received from Prof. Clark, as well as others adhering to topaz specimens from Schneckenstein in Prof. Brush's collection. These crystals are, however, too small for measurement by the means at our command. If the angle given by Prof. Knop be correct, we presume that more exact goniometry would prove the same true of the kaolinite from Summit Hill, the crystals of which, being six times larger in linear dimensions, we have measured without difficulty, though not with great precision. In our figures of the last named substance, drawn by the camera lucida, the angles vary one and in some cases two degrees; but they never fall below 118°, the opposite angles vary as much as those contiguous to each other, and they all point to 120° as the mean.

Prof. Knop has also favored us with a portion of the kaolin from Zeisigwald before referred to. The plates average ·0002 inch in breadth, and are finer than those of some plastic clays we have examined. Under an $\frac{1}{8}$ in. objective we have detected short bundles of plates, but in a cursory examination did not discover plates with a definite angular outline.

As regards pholerite, we learn from Prof. Knop's paper, that the mineral from Niederrabenstein, described by him, is not a homogeneous substance, but in the sample analyzed contained 7·91 per cent of quartz and other impurities, insoluble in concentrated sulphuric acid. The analysis quoted in our table is that of the portion soluble in sulphuric acid.

The substance itself, known as *Thonstein* or *Felsittuff*, was of close texture, easily cut by the knife and appeared when "magnified 330 diameters as a mass of fine crystalline colorless scales, which were of themselves only in part well defined or aggregated in parallel position to small thick packets."

This description agrees with what we have given of various clays, and leads to one of two conclusions, viz., either the substance is impure kaolinite, or, if pholerite, the latter has an appearance and prismatic crystallization closely similar to kaolinite.

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In his analysis, Prof. Knop decomposed the substance by hot concentrated sulphuric acid, evaporated off the excess of this acid, warmed with chlorhydric acid, and dissolved in distilled water. From the undissolved residue silica was extracted by solution of caustic soda. There is one point in this method that is open to objection and might introduce a serious error in the results. In evaporating off the excess of sulphuric acid which requires a high temperature, the heat may easily rise at the close of the operation to a degree at which silica decomposes sulphate of alumina, and on subsequent treatment with chlorhydric acid, soluble silica would pass into the liquid and be included in the alumina precipitate, unless special precautions were taken. For this reason we do not regard the single analysis as conclusive of the existence of pholerite.

It is further to be observed that the pure kaolinite of Zeisigwald occurs in the same neighborhood and in cavities in a similar "thonstein."

The Naxos pholerite analyzed by Prof. J. L. Smith is described as associated with emerylite. But for the great care which Prof. Smith is known to employ in the selection of pure material, we might suppose he analyzed a mixture of kaolinite and emerylite. In fact, if we assume the 1·21 per cent of lime in his analysis to belong to emerylite, and calculate the corresponding quantities of silica, alumina and water, according to the theoretical composition of this substance as given in his paper, we obtain, after deducting these quantities from the per-centages in "pholerite," proportions of silica, alumina and water that represent kaolinite quite closely.

	Supposed pholerite.	Emerylite, calc. from lime.		Residue.	Residue calc. on 100. (kaolinite?)
$\dot{S}i$,	44·41	2·93	=	41·48	45·57
$\dot{A}l$,	41·20	4·42	=	36·78	40·40
$\dot{C}a$,	1·21	1·21			
$\dot{H}$,	13·14	0·38	=	12·76	14·01
	99·96	8·94	=	91·02	99·98

We do not regard such calculations as conclusive, but their indications are worthy of being followed up. S. W. J. and J. M. B.

6. *On a new specimen of Telerpeton Elginense;* by Prof. T. H. Huxley, LL.D., F.R.S., V.P.G.S.—The specimen which was described in this paper had been broken into five pieces, exhibiting hollow casts of most of the bones of *Telerpeton Elginense.* It is the property of Mr. James Grant of Lossiemouth, and came from the reptiliferous beds of that locality, along with some highly interesting fragments of *Stagonolepis* and *Hyperodapedon.* The casts described by the author consisted of impressions of the bones of the skull, together with the lower jaw, and the teeth; of most of the vertebræ and ribs; of the greater portions of the pelvic and scapular arches; and of representatives of most of the bones of the fore and hind limbs; and it was stated that the characters of all these portions of the skeleton indicated decidedly Lacertilian affinities.

In describing these remains Professor Huxley discussed especially the biconcave character of the vertebræ; the mode of implantation of the teeth, which he believed to be acrodont, and not thecodont; and the anomalous structure of the fifth digit of the hind foot, which presents only two phalanges (a proximal and a terminal), a structure which differs from that of all known Lacertilian reptiles, whether recent or fossil. His

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researches had led him to conclude that the animal is one of the Reptilia, and is devoid of the slightest indication of affinity with the Amphibia. In all its characters it is decidedly Saurian, and accords with the sub-order *Kionocrania* of the true Lacertilia; but the author had not been able to make sure that it possesses a columella. He also remarked that the possession by *Telerpeton Elginense* of vertebræ with concave articular faces does not interfere with this view, as although most recent Lacertilia have concavo-convex vertebræ, biconcave vertebræ much more deeply excavated than those of *T. Elginense* are met with among the existing geckos.

Professor Huxley in conclusion drew attention to the interesting fact that *Telerpeton* presents not a single character approximating it toward the type of the Permian *Protorosauria*, or the Triassic *Rhynchosaurus*, and other probably Triassic African and Asiatic allies of that genus, or to the Mesozoic Dinosauria; and that whether the age of the deposit in which it occurs be Triassic or Devonian, *Telerpeton* is a striking example of a *persistent type* of animal organization.—*Geol. Mag.*, iv, 78.

7. *Note on Taltalite;* by F. Pisani. (From a letter to J. D. Dana, dated Paris, Dec. 6, 1866.)—*Taltalite* of Domeyko,* recently described by Mr. David Forbes,† comes from a copper mine of Señor Moreno near Taltal, in the desert of Atacama, where it is associated with atacamite and copper glance. It occurs in large masses, fibrous, silky in luster, brownish-black in color, and has a dark gray powder. Domeyko obtained

$\dddot{Si}$	$\dddot{Al}$	$\dddot{Fe}$	$\dot{Mg}$	$\dot{Ca}$	$\dot{Cu}$	Cl	$\dot{H}$	
20·8	16·2	11·3	0·8	2·4	44·5	0·7	2·25	= 98·95

affording the oxygen ratio for the bases and silica 21·83 : 11·08.

On a close examination of the mineral I have found that it is only a mixture of fibrous tourmaline and oxyd of copper. Treated with chlorhydric acid, it leaves a residue which contains boracic acid, and has the reactions of tourmaline; and the solution includes all the copper with but very little iron, no cobalt or manganese, and traces of lime. Besides, if from Domeyko's results we take all the oxyd of copper which the acid takes up, we obtain for the remainder—

$\dddot{Si}$ 38·7 $\dddot{Al}$ 30·1 $\dddot{Fe}$ 21·2 $\dot{Mg}$ 1·49 $\dot{Cu}$ 4·41 $\dot{H}$ 4·1 = 100.

These numbers agree with those of a very ferriferous tourmaline, excepting the absence of boracic acid which Domeyko did not detect. I have in my collection a specimen of blackish-brown fibrous tourmaline from Chili, which is free from oxyd of copper. What has been called *taltalite* is similar, excepting the accidental mixture of oxyd of copper.

8. *On the punctate shell structure of Syringothyris;* by F. B. Meek. (From a letter to one of the editors, dated Washington, April 18th, 1867.)—I write a brief note to inform you that I have recently examined Prof. Winchell's types of his genus *Syringothyris*, which he was so kind as to loan me, and that I find them all, with the exception of two silicified specimens (showing no structure), *distinctly punctate.* It is probable that Prof. Winchell had happened to examine chippings from specimens not in a condition to show the punctures. I have likewise ascertained, since the publication of my former paper on this subject, that *Spirifer propinquus* Hall, and *S. Hannibalensis* Swallow, both nearly

* Domeyko's Mineralogy, 2d edit., p. 139, 1860. † Phil. Mag., [4], xxv, 111.

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like *S. cuspidatus*, have a clearly punctate structure, and hence probably belong to the group *Syringothyris*.

I have also just read a letter from Mr. Davidson, written to Mr. Worthen, in which he quotes, from a letter to him from Dr. Carpenter, a paragraph giving the results of his examinations of specimens of *Syringothyris*, and of the same Irish shell examined by me (and at one time supposed to be *Spirifer cuspidatus*). These chippings were sent over by Mr. Worthen at Mr. Davidson's request some little time back. Dr. Carpenter says he finds the *Syringothyris* (that from Floyd Co., Indiana, I suppose) *distinctly punctate*, the punctures being as I stated, small and scattering. The chippings from the Irish specimen, sent over to Mr. Worthen with the name *S. cuspidatus* attached, Dr. Carpenter also found to be punctured, though the punctures are not so clearly seen as in the other. Chippings of *S. subcuspidatus* Hall, sent by Mr. Worthen, he says are not in a condition to show the structure.

At the time of writing, Dr. Carpenter had evidently not received a package of chippings I had sent him, containing specimens of *S. subcuspidatus* showing the punctures clearly. He says these examinations of the structure of *Syringothyris* confirm its generic or subgeneric differentiation established upon other characters, and that the Irish specimen he believes belongs to this group. He is still confident, however, that the *true S. cuspidatus* is not a punctate shell, which you will remember I had not supposed to be the case. I never doubted or questioned the accuracy of Dr. Carpenter's conclusions on that point; and there is no microscopist living in whose results I have more confidence than in his.*

9. *Geological Researches in China, Mongolia, and Japan during the years* 1862 *to* 1863; by RAPHAEL PUMPELLY. 144 pp., 4to, with 9 plates. Washington City. Published by the Smithsonian Institution, being No. 202 of the Smithsonian Contributions to Knowledge.—In vol. xli of this Journal, Mr. Pumpelly gave a very brief notice of the principal results to which he had arrived after his explorations in China and Japan. The volume issued contains a full account of his very interesting observations. It treats of the General Outlines of Eastern Asia; its general geology, with an account of his special explorations in China and Japan; the structure of the Southern edge of the Great Table-Land, and of Northern Shansi and Chihli; the Sinian system of elevation; the Yellow Stone and its delta and changes of course; and the Mineral Productions of China; and gives, in an Appendix, Dr. Newberry's descriptions of the Fossil Plants of the Coal rocks, with plates; J. A. Macdonald's analyses of Chinese and Japanese Coals; and the results of Mr. A. M. Edwards's microscopic examination of some Japanese infusorial earths and other deposits of China and Mongolia.

The Sinian system of elevation is the "extensive N.E. and S.W. system of upheaval, which is traceable through nearly all Eastern Asia, and to which this portion of the continent owes its most salient features." It is stated

* In a paper on certain types of the Spiriferidæ published in the Proceedings of the American Philosophical Society for 1866, and presented to that Society in May of 1866, Mr. J. Hall presents facts confirming my observations, communicated in a paper read before the Philad. Acad. Nat. Sci., in Dec. 1865, and published Feb. 1866, in which the presence of a punctate structure in shells of this type, and its coincidence with the internal tube of *Syringothyris*, were first announced. He, however, makes no allusion to my investigations, of which he certainly was not ignorant.

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to be extensively apparent in the courses of the mountains, the strike of the strata, and the hydrography. It characterizes the trend of the metamorphic rocks over the plateau from Mongolia from the Great Wall to Siberia; and a map shows that it belongs to all Eastern Siberia, the Yablonvi, Altan-Kingan, and Stanovoi Mts., with their intermediate ridges, conforming to it. The period of the uplift is placed before that of the Coal-measures (Mesozoic). Mr. Pumpelly remarks that striking analogies are observed to exist between the Sinians and our own Appalachians, as to structure, strike, and dip; and that as the elevation of the Appalachians determined the outline of Eastern America, so the Sinian revolution fixed the eastern boundary of the great Asiatic continent.

10. *Nuove Osservazioni Geologiche sulle Rocce Anthracitifere delle Alpi;* del Commendatori ANGELO SISMONDA, Prof. di Min. nella Regia Universita di Torino. 26 pp., 4to, with colored maps. Turin, 1866.—Prof. Sismonda, in this paper, treats of the age of certain stratified rocks occurring among the metamorphic of the Alps of Savoy, which contain anthracite and plants of the Carboniferous age along with remains of animals of Liassic and Oolitic age. Sismonda concludes that there are three consecutive groups of these rocks; a lower, which is Liassic in its mollusks; a middle, with Liassic and Oolitic fossils; and above this a quartzose conglomerate and sandstone with anthracite, and supposed to be of the age of the Oxfordian clay. The Carboniferous plants are found both in the lower and upper.

11. *Ueber ein Æquivalent der takonischen Schiefer Nordamerika's in Deutschland und dessen geologische Stellung;* von Dr. H. B. GEINITZ und Dr. K. Th. LIEBE, Professoren in Dresden und Gera. 52 pp., 4to, with 8 lithographic plates and several wood-cuts.—The plates of this memoir contain figures of different Annelids and Fucoids from the slates near Wurzbach, which bear much resemblance to those that occur in rocks *called* Taconic in North America.

12. *Note on the genus Palæaster and other Fossil Starfishes*, with descriptions of some new species; by JAMES HALL. 24 pp., 8vo. From the Twentieth Report on the State Cabinet of Natural History. Published (to page 21) in advance of Report, Nov. and Dec., 1866.

13. *Descriptions of some new species of Crinoidea and other fossils* from the Lower Silurian strata of the age of the Hudson River Group and Trenton limestone; by JAMES HALL. Printed, in advance, from the Report on the State Cabinet for 1866, and issued Nov. 1866.

III. BOTANY AND ZOOLOGY.

1. *Catalogus Plantarum Cubensium, exhibens Collectionem Wrightianum aliasque minores ex Insula Cuba missas quas recensuit* A. GRISEBACH, Professor Göttingensis. pp. 301, 8vo. Leipsic, 1866. (Engelmann.) —Although printed a year ago (the preface bears the date of April, 1866), the derangements incident to the short war which last summer wrought such changes in Germany, in some way delayed until recently the publication of this little volume. It is now to be had of B. Westermann & Co., 440 Broadway, New York; and it is indispensable to those botanists who possess any part of Mr. Wright's rich Cuban collections of botanical specimens, which are cited by the numbers under which they were distributed. A goodly number of clerical or typographical errors (beyond those

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indicated on pp. 287, 288), as also errors in the distribution, call for correction. It is to be hoped that Mr Wright will some day print a revised list in the order of their numbers. Meanwhile the writer of this notice will furnish to any possessors of these specimens who apply for them such corrections as he has been able to make in his own copy. As might have been expected the flora of Cuba proves to be very rich. This Catalogue contains—

Dicotyledons,	2350,	of which	781	are peculiar	to the	Island.
Monocotyledons,	634	"	148	"	"	"
Vascular Cryptogamia,	279	"	10	"	"	"
Total,	3263	"	939	"	"	"

And Mr. Wright's more recent explorations, which are still in progress, will largely increase the number. If Hayti could now be equally explored, the flora of the West Indies could be written with some approach to perfection.

Characters of the new species only (and these are very many) are given in this volume. The diagnoses of the new *Euphorbiaceæ* are, however, unfortunately omitted, having been published by anticipation, in the Nachrichten of the Göttingen Royal Society of Science. Now that we have, thanks to Professor Grisebach's studies, so good a foundation for Cuban botany, we may hope that our indefatigable explorer may crown his prolonged and laborious researches by a general revision of the flora of the island. A. G.

2. *Flora Australiensis*, Vol. III. *Myrtaceæ* to *Compositæ*, 1866.—This great work makes rapid progress in Mr. Bentham's able hands. The present volume comprises the largest and most difficult Australian order, the *Myrtaceæ*, and the usually paramount order *Compositæ*, these two filling a little more than three quarters of the 680 pages of this volume, which also contains the *Umbelliferæ* and the *Rubiaceæ*, usually of no small size. A. G.

3. *The Geographical Distribution of Mammals;* by ANDREW MURRAY. 420 pp., 4to, with 105 chromo-lithographic maps. London, 1866. (Day & Son.)—This beautiful volume treats those subjects *in extenso* which are merely glanced at in the physical atlases of Johnston and others, including the distribution of fossil species according to their geological position, and discussions of the views of Agassiz and Darwin, without adopting either in full. The work extends to forty-three chapters, with an extended appendix and numerous cuts illustrating animal peculiarities.

Geological questions are discussed and maps given of the 100-fathom line of soundings; the effect of a depression of the land 600 feet; Tertiary and Quaternary formations; localities of glacial action; rising and falling of land of the present period; and the sargasso seas. The maps of mammal distribution then commence with the human race, chapter vii, p. 56, but two branches of which are acknowledged, the black and white, the latter including all except the negroes and Australians, with their affinities.

The completeness of the work may be judged from the extent to which groups and genera are located. Maps 7–10 are devoted to the distribution of monkeys; 13, to the lion; 14, to the tiger; 17, fossil hyenas; 18, existing hyenas; 26, bears; 29, hippopotamus (living and fossil);

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30, swine; 34, goats; 35, sheep; 46, rhinoceros (living and extinct); 47, mastodons and elephants in Lower Miocene; 48, in Upper Miocene; 49, in Pliocene; and 50, existing elephants.

The appendix (pp. 312–412) is devoted to the classification of mammals proposed by different authors; a synonymic list of the species and their localities, distinguishing the extinct species; and mammals of special districts, as Spitzbergen, Nova Zembla, Greenland, Iceland, Sweden, France, Sahara, Japan, &c. North America is given under eight districts exclusive of Mexico.

A work of so much value, published in a style which precludes a return for the outlay, should have a place in the libraries of all who wish to encourage research in the cognate fields upon which the learned author is understood to be engaged. S. S. H.

4. *Observations on the Genus Unio, together with Descriptions of new species in the Family Unionidæ, and Descriptions of new species of the Melanidæ, Limneidæ, Paludinæ, and Helicidæ;* by ISAAC LEA, LL.D. 146 pp., 4to, with 24 plates. Philadelphia. (Read before the Academy of Natural Sciences of Philadelphia, and published in their Journal.)—This volume is the eleventh in Dr. Lea's series on the Unionidæ. Like the preceding, it contains very large additions to the number of species, and is beautifully and generously illustrated. The introduction states that the number of new species of Unionidæ here described is 180, and of the other groups mentioned above, 118. The former are mainly from the Southern States, a few from Western Asia, and Lake Nyassa in Central Africa. The univalves are mostly of the U. States, but some are from Central America and Asia.

5. *An Inquiry into the Zoological relations of the first discovered traces of Fossil Neuropterous Insects in North America: with Remarks on the difference of structure in the wings of living Neuroptera;* by S. H. SCUDDER. 20 pp., 4to. From Vol. I of the Mem. of the Bost. Soc. Nat. Hist., Jan. 1865.—The paper discusses the characters of the fossil insects from the coal rocks of Illinois, described in vol. xxxvii of this Journal, with results of great interest to science.

6. *On the Osteology and Myology of Colymbus torquatus;* by ELLIOTT COUES, A.M., M.D., Brevet Capt. and Assist. Surgeon, U.S. Army. 42 pp., 4to. From vol. I of the Mem. of the Bost. Soc. Nat. Hist., Nov. 1866.

7. *Notes on the Zygænidæ of Cuba;* by A. R. GROTE. 18 and 38 pp., 8vo, with plates. From the Proceedings of the Entomological Society of Philadelphia, Part I, July, 1866, and Part II, Jan., 1867.

IV. ASTRONOMY.

1. *On the Obscuration of the Lunar Crater "Linné;"* by W. B. BIRT, Esq.—The interesting phenomenon of a change in the appearance of the crater "Linné" was communicated to me by Herr Schmidt, the Director of the Observatory at Athens, an extract from whose letter is as follows:

"For some time past I find that a lunar crater situated in the plain of the *Mare Serenitatis* has been invisible. It is the crater which Mädler named Linné, and is in the fourth section of Lohrmann, under the sign A. I have known this crater since 1841, and even at the full it has not been difficult to see. In October and November, 1866, at its epoch of

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maximum visibility, i. e., about the time of the rising of the sun on its horizon, this deep crater, whose diameter is 5·6 English miles, had completely disappeared, and in its place there was only a little whitish luminous cloud. Be so kind as to make some observations on this locality."

The earliest information respecting the crater I received from Mr. Buckingham, who favored me with a copy of a photograph taken by him on November 18, 1866. On this photograph the place of "Linné" is visible, but faint. I have during the last lunation received records of observations from the following gentlemen: Doctors Mann and Tietjen, and Messrs. Talmage, Webb, Slack, Grover, and Jones. On the 13th, when the terminator passed over the east boundary of the *Mare Serenitatis*, the place of "Linné" was seen by Messrs. Webb and Talmage; Mr. Webb's aperture 9¼-inch silvered glass reflector, and Mr. Talmage's 10-inch refractor of Mr. Barclay at Leyton. Mr. Webb described the appearance as an ill-defined whitishness on the site of "Linné." Mr. Talmage recorded "a dark circular cloud." The exact position of these appearances was carefully ascertained afterward and found to agree with the place of "Linné." Doctor Mann and myself at Leyton were prevented by a thin veil of cirrus seeing the "cloud" recorded by Mr. Talmage. With smaller apertures both Mr. Grover and myself were unable to detect the slightest trace of "Linné," while the small crater "Linné B" of Beer and Mädler, and also Bessel, were very distinct *with the shadows within them.* On the following evening, December 14th, observations were made by Messrs. Webb, Slack, Grover, and Birt. A white spot was seen in the position of "Linné." Mr. Webb described it as the most conspicuous object on the east half of the *Mare Serenitatis.* Mr. Slack saw a whitish spot not remarkably bright, but could see no trace of a crater. Mr. Grover recorded "a tolerably defined roundish whitish speck," but he could not see the interior or margin of the crater, and "in this respect the spot showed very different from Bessel and other craters which were well seen." My own observations perfectly agree with the above. I estimated the light at 3°. On the 15th the spot was brighter, and I obtained the measures recorded below. On the 16th Messrs. Jones and Grover described the appearance as a white spot not over bright.

On the 20th Professor Foërster and Dr. Tietjen observed "Linné" with the Berlin refractor. The following is the translation of the letter which I received from Dr. Tietjen, dated Berlin, 21 December, 1866:

"On viewing the moon last night about 13^h M.T. Berlin with our refractor, in order to convince ourselves of the disappearance of the crater 'Linné,' Professor Foërster and myself perceived that crater very distinctly. If, therefore, an obscuration has taken place, on which certainly no doubt can exist, as it is affirmed by so competent an authority as Herr Schmidt of Athens, it has evidently now ceased."

Although Dr. Tietjen considers that the obscuration *has ceased*, it does not appear that either he or Professor Foërster *has seen into* the crater.

The whole of the observations are so accordant among themselves, and the measures appended so clearly indicate the white spot to be larger than the crater "Linné," as to leave no doubt that a change of some kind has taken place; and this conclusion appears to be supported by previous records which are here appended:

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Date.	Authority.	Brightness.
1653,	Riccioli.	o
1788, Nov. 5,	Schröter,	0·5
1823, May 28,	Lohrmann,	7·0+
1831, Dec. 12, 13,	Beer and Mädler,	6·0
1858, Feb. 22,	De la Rue,	5·0
1865, Oct. 4,	"	5·0
	Rutherfurd,	6·0
1866, Nov. 18,	Buckingham,	2·0

The last four determinations of brightness are from photographs. There is some uncertainty in determining this element on the prints. Schröter, in plate IX of his Selenophotographische Fragmente, gives a large dark spot in the place of "Linné;" and the Rev. T. W. Webb informs me that "Linné" is not to be found on Russell's globe or maps, 1797, from which it may be inferred that the crater has previously been obscured.

The following measures were made during the last lunation:

Date. 1866.	Dionysius.	Linné.	Mag.	Miles.	Brightness.
	″	″			o
Dec. 15	14·70	11·61	0·79	10·9	4
18	14·13	7·07	0·50	6·9	5·5
19	13·95	7·32	0·52	7·2	5
21	13·32	6·75	0·51	7·0	4

The numbers in column 4 headed "Mag." are obtained by dividing the measures of "Linné" by the measures of the standard spot "Dionysius." The normal magnitude of "Linné" is 0·40 ("Dionysius" being unity) as determined by two independent methods. The numbers in column 5 headed "Miles" are not absolute, but only relative as compared with "Dionysius," by means of the numbers in column 4. "Dionysius," according to Lohrmann, is 13·8 English miles, and "Linné," according to Schmidt, 5·6 English miles in diameter. During the lunation no trace of the *crater* was seen.—*Monthly Notices Roy. Astr. Soc.*, Jan. 11, 1867.

2. *Shooting Stars seen in Colorado.*—The Denver News gives the following numbers of meteors seen at that place (N. lat. 39° 40′, W. long. 105°) in intervals of five minutes at different times on the morning of Nov. 14th, 1866. The number of observers is not stated.

At 12h	0m,	5 meteors.	At 1h	25m,	5 meteors.	At 3h	30m,	5 meteors.
12	20	8 "	2	0	5 "	4	0	12 "
12	30	7 "	2	30	14 "	5	15	10 "
12	45	9 "	2	45	11 "			
1	0	4 "	3	0	21 "	Total in 65m,		101 "

3. *Astronomical and Meteorological Observations made at the United States Naval Observatory during the year* 1864. Captain J. M. Gilliss, U.S.N., Superintendent. 524 pp., 4to. Published by authority of the Hon. Secretary of the Navy. Washington, 1866.—This important volume contains the following tables: (1.) Observations with the Meridian Transit Instrument; (2.) ib. with the Mural Circle; (3.) ib. with the Equatorial; (4.) Mean right ascensions, for 1860·0 of stars observed with the Transit; (5.) Mean declination, obs. with the Mural Circle; (6.) Right ascensions, declinations, and semi-diameters of the Sun, Moon, and Planets; (7.) Constants for the reduction of fixed stars; (8.) Catalogue of stars observed in 1864; (9.) Meteorological observations.

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V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Additional Gifts to Science from George Peabody, Esq.*—Since the notice of Mr. Peabody's recent donations to science, which appeared in the January number of this Journal, this gentleman has given about $2,000,000 for the promotion of education in the South and Southwest. This munificent gift was accompanied by the following letter to the Trustees of the fund:—

To Hon. Robert C. Winthrop, of Massachusetts; Hon. Hamilton Fish, of New York; Right Rev. Charles P. McIlvaine, of Ohio; General U. S. Grant, of the United States Army; Admiral David G. Farragut, of the United States Navy; Hon. William C. Rives, of Virginia; Hon. John H. Clifford, of Massachusetts; Hon. William Aiken, of South Carolina; William M. Evarts, Esq., of New York; Hon. William A. Graham, of North Carolina; Charles Macalester, of Pennsylvania; George W. Riggs, Esq., of Washington; Samuel Wetmore, Esq., of New York; Edward A. Bradford, Esq., of Louisiana; George N. Eaton, Esq., of Maryland; and George Peabody Russell, Esq., of Massachusetts.

GENTLEMEN: I beg to address you on a subject which occupied my mind long before I left England, and in regard to which, one at least of you (the Hon. Mr. Winthrop, the distinguished and valued friend to whom I am so much indebted for cordial sympathy, careful consideration, and wise counsel in this matter) will remember that I consulted him immediately upon my arrival in May last.

I refer to the educational needs of those portions of our beloved and common country which have suffered from the destructive ravages, and the not less disastrous consequences of civil war.

With my advancing years my attachment to my native land has but become more devoted. My hope and faith in its successful and glorious future have grown brighter and stronger, and now, looking forward beyond my stay on earth, as may be permitted to one who has passed the limit of three score and ten years, I see our country united and prosperous, emerging from the clouds which still surround her, taking a higher rank among the nations, and becoming richer and more powerful than ever before.

But to make her prosperity more than superficial, her moral and intellectual development should keep pace with her material growth; and in those portions of our nation to which I have referred, the urgent and pressing physical needs of an almost impoverished people must for some years preclude them from making, by unaided effort, such advances in education, and such progress in the diffusion of knowledge among all classes, as every lover of his country must earnestly desire.

I feel most deeply, therefore, that it is the duty and privilege of the more favored and wealthy portions of our nation to assist those who are less fortunate; and, with the wish to discharge so far as I may be able my own responsibility in this matter, as well as to gratify my desire to aid those to whom I am bound by so many ties of attachment and regard, I give to you, gentlemen, most of whom have been my personal and especial friends, the sum of one million of dollars, to be by you and your

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successors held in trust, and the income thereof used and applied in your discretion for the promotion and encouragement of the intellectual, moral, or industrial education among the young of the more destitute portions of the Southern and Southwestern States of our Union; my purpose being that the benefits intended shall be distributed among the entire population, without other distinction than their needs and the opportunities of usefulness to them.

Besides the income thus derived, I give to you permission to use from the principal sum, within the next two years, an amount not exceeding forty per cent.

In addition to this gift I place in your hands bonds of the State of Mississippi, issued to the Planter's Bank, and commonly known as Planter's Bank Bonds, amounting, with interest, to about eleven hundred thousand dollars, the amount realized by you from which is to be added to and used for the purposes of this trust. * * * * * * *

The details and organization of the trust I leave with you, only requesting that Mr. Winthrop may be Chairman, and Governor Fish and Bishop McIlvaine Vice-Chairmen of your body; and I give to you power to make all necessary by-laws and regulations, to obtain an act of incorporation, if any shall be found expedient, to provide for the expenses of the trustees and of any agents appointed by them, and generally, to do all such acts as may be necessary for carrying out the provisions of this trust.

All vacancies occurring in your number by death, resignation, or otherwise, shall be filled by your election, as soon as conveniently may be, and having in view an equality of representation so far as regards the Northern and Southern States.

I furthermore give to you the power, in case two-thirds of the trustees shall at any time, after the lapse of 30 years, deem it expedient, to close this trust, and of the funds which at that time shall be in the hands of yourselves or your successors, to distribute not less than two-thirds among such educational or literary institutions, or for such educational purposes as they may determine, in the States for whose benefit the income is now appointed to be used. The remainder may be distributed by the trustees for educational or literary purposes wherever they may deem it expedient.

In making this gift I am aware that the fund derived from it can but aid the States which I wish to benefit in their own exertions to diffuse the blessings of education and morality. But if this endowment shall encourage those now anxious for the light of knowledge, and stimulate to new efforts the many good and noble men who cherish the high purpose of placing our great country foremost, not only in power, but in the intelligence and virtue of her citizens, it will have accomplished all that I can hope.

With reverent recognition of the need of the blessing of Almighty God upon this gift, and with the fervent prayer that, under his guidance, your counsels may be directed for the highest good of present and future generations in our beloved country, I am, gentlemen, with great respect, your humble servant, GEORGE PEABODY.

Washington, Feb. 7, 1867.

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More recently Mr. Peabody has given $140,000 to the Essex Institute in Salem, Mass., for the promotion of the Natural and Physical Sciences in his native county. Of this sum $100,000 is to be kept as a permanent fund, and the income to be devoted to various branches of science. The remainder of the gift will be chiefly expended on the Museum of Natural History. Mr. Peabody's letter to his Trustees announcing this donation was as follows:—

Salem, Feb. 26, 1867.

To Francis Peabody, Esq., Prof. Asa Gray, Wm. C. Endicott, Esq., Geo. Peabody Russell, Esq., Prof. O. C. Marsh, Henry Wheatland, A. C. Goodell, Jr., James R. Nichols, and Henry C. Perkins, Esqs.

Gentlemen: As you will perceive by the inclosed instrument of Trust, I wish to place in the hands of yourselves and your successors, the sum of one hundred and forty thousand dollars, for the promotion of Science and Useful Knowledge in the County of Essex.

Of this, my native county, I have always been justly proud, in common with all her sons, remembering her ancient reputation, her many illustrious statesmen, jurists and men of science; her distinguished record from the earliest days of our country's history, and the distinction so long retained by her, as eminent in the education and morality of her citizens.

I am desirous of assisting to perpetuate her good name through future generations, and of aiding through her means in the diffusion of science and knowledge; and, after consultation with some of her most eminent and worthy citizens, and encouraged by the success which has already attended the efforts and researches of the distinguished Scientific Association of which your Chairman is President, and with which most of you are connected, I am led to hope that this gift may be instrumental in attaining the desired end.

I therefore transmit to you the inclosed instrument, and a check for the amount therein named ($140,000), with the hope that this Trust, as administered by you and your successors, may tend to advancement in intelligence and virtue, not only in our good old county of Essex, but in our Commonwealth, and in our common country.

I am, with great respect, your humble servant,

(Signed) GEORGE PEABODY.

Mr. Peabody has, moreover, recently given $20,000 to the Massachusetts Historical Society, and $15,000 each to Newburyport, Mass., and Georgetown, D. C., to found free public libraries in those cities.

These various gifts increase the amount of Mr. Peabody's recent benefactions to science and education in this country to nearly four millions dollars,—a truly noble and unparalleled record of private munificence.

2. *Ascent of Mount Hood, Oregon;* by the Rev. H. K. HINES.*—In September of 1864, in company with three gentlemen of Vancouver, I first attempted to reach the summit of Mount Hood. On reaching an altitude about 800 feet below the summit, a dense cloud came sweeping against the north side of the mountain, and, drifting rapidly over it, instantly enveloped us in its folds. The air changed suddenly to a fierce cold. The driving snow filled the air so entirely that a cliff of rocks 300 feet high, standing not more than fifty feet from us, was invisible.

* From the Proceedings of the Royal Geographical Society, March 23, 1867.

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To go up or to go down, was, for the time, alike impossible. One of my companions was chilled nearly to insensibility, but we struggled against the tempest for hours, unwilling to be defeated in our purpose to reach the summit.

On the morning of the 24th of July, 1866, in company with three gentlemen of the city of Portland, Oregon, I set out full of determination to stand upon the summit, if energy and endurance could accomplish the feat. Our rendezvous was at the house of a Canadian, who, fourteen years before, had erected a cabin at the place where the emigrant road leaves the mountains and enters the valley of the Willamette. From this place the track enters the mountains along the gorge through which flows a dashing river about 300 feet in width, which r ses beneath the glaciers of Mount Hood. Up this stream we travelled for 30 miles, when, leaving the gorge, the way makes a *détour* to the south to gain the summit ridge. Here is the celebrated "Laurel Hill." For three or four miles the ascent is continuous, and in many places very steep.

Reaching the top of Laurel Hill we were on the general summit of the range: a comparative level of perhaps 10 miles in width, whose general character is that of a swamp or marsh. On this plateau is a dense and grand growth of fir, cedar (*Thuja gigantea*, Nutt.), pine and kindred evergreens, with an almost impenetrable undergrowth of laurel (*Rhododendron maximum*, Hook). Straggling rays of sunlight only here and there find way through the dense foliage to the damp ground. Passing over this level we crossed several bold clear streams, coursing down from the direction of Mount Hood, and then, turning to the left, we took an old Indian trail leading in the direction of the mountain. After a ride of an hour and a half up a continuous and steep ascent, we came to an opening of scattered trees which sweeps around the south side of the mountain. It was about five o'clock when we emerged from the forest, and stood confronting the wonderful body of rock and snow which springs up from the elevation.

We selected a place for our camp on a beautiful grassy ridge between one of the main affluents of the Deschutes river and one of the Clackamas, and which nearly constitutes the dividing ridge of the mountain. Having erected here a hut of boughs and gathered fuel for a large fire during the night, we spread our blankets on the ground and slept well until the morning. We picketed our horses in this place. At seven o'clock of Thursday we were ready for the ascent. For the first mile and a half the ascent was very gradual and easy, over a bed of volcanic rock, decayed and intermixed with ashes. Huge rocks stood here and there, and occasionally a stunted juniper found a precarious foothold; some beautiful variegated mosses were also seen clinging to little knolls of sand. We soon reached the foot of a broad snow-field, which sweeps around the south side of the mountain several miles in length, and extending upward to the immediate summit. The first part of this ascent is comparatively easy, being smooth, and only in places so steep as to render the footsteps uncertain. Near the upper edge of this field of snow, the deep gorges, from which flow affluents of the streams Deschutes on the right, and Sandy river on the left, approach each other and seem to cut down into the very foundation of the mountain. The

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waters were rushing from beneath the glaciers, which at their upper extremity were rent and broken into fissures and caverns of unknown depths.

The present summit of the mountain is evidently what was long since the northern rim of an immense crater, which could not have been less than three miles in diameter. The southern wall of the crater has fallen completely away, and the crater itself become filled with rock and ashes overlaid with the accumulated snows of ages, through the rents and chasms of which now escape smoke, steam and gases from the pent-up fires below. The fires are yet so near that many of the rocks which project upward are so hot that the naked hand cannot be held upon them. Just at the southwest foot of the circular wall, now constituting the summit, and at a distance of near 2000 feet from its extreme height, is now the main opening of the crater. From this a column of steam and smoke is continually issuing, at times rising and floating away on the wind, at other times rolling heavily down the mountain. Into this crater we descended, as far as it was possible to go without ropes or a ladder. The descent was stopped by a perpendicular precipice of ice 60 or 70 feet high, resting below on a bed of broken rock and ashes so hot as immediately to convert the water, which dripped continually from the icy roof 100 feet above, into steam. The air was hot and stifling.

At this point the real peril of the ascent begins. It leads out and up the inner wall of what was once the crater, and near 1000 feet of it is extremely steep. The whole distance is an ice-field, the upper limit of a great glacier which is crushing and grinding its slow journey down the mountain far to the right. About 700 feet from the summit a *crevasse*, varying from 5 to 50 feet in width, and of unknown depth, cuts clear across the glacier from wall to wall. There is no evading it. The summit cannot be reached without crossing it. Steadily and deliberately poising myself on my staff, I sprang over the chasm at the most favorable place I could select, landing safely on the declivity 2 or 3 feet above it, and then with the staff assisted the others to cross. The last movement of 15 feet had considerably changed the prospect of the ascent. True, the crevasse was passed, but we were thrown directly below a wall of ice and rocks 500 feet high, down which masses, detached by the heat of the sun, were plunging with fearful velocity. To avoid them it was necessary to skirt the crevasse on the upper side for a distance, and then turn diagonally up the remaining steep. It was only 700 feet high, but it was two hours' sinewy tug to climb it. The hot sun blazed against the wall of ice within two feet of our faces, and the perspiration streamed from our brows, but on nearing the summit the weariness seemed to vanish, and with a feeling of triumph we bounded upon the pinnacle of the highest mountain in North America.

The summit was reached at about the center of the circular wall which constitutes the extreme altitude, and it was so sharp that it was impossible to stand erect upon it. Its northern face is an escarpment several thousand feet high. I could only lie down on the southern slope, and, holding firmly to the rocks, look down the awful depth. A few rods to the west was a point 40 or 50 feet higher, to the summit of which we crawled, and then discovered that 40 or 50 rods to the east was a point

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still higher, the highest of the mountain. We crawled back along the sharp escarpment, and in a few minutes stood erect on the highest pinnacle. This we found to be 17,640 feet high, the thermometer standing at 180°, about 40 feet below the summit, when the water boiled—giving 32 degrees of depression. This estimate makes Mount Hood higher than any summit of Europe or North America.

The view from the summit was magnificent. From south to north the whole line of the Cascade Range is at once under the eye, from Diamond Peak to Ranier, a distance of not less than 400 miles. Within that distance are Mounts St. Helen's, Baker, Jefferson, and the Three Sisters; making, with Mount Hood, eight snowy peaks. Eastward the Blue Mountains are in view, and lying between us and them are the broad plains watered by the Deschutes, John Day's, and Umatilla rivers. On the west the piny crests of the coast range cut clear against the sky, with the Willamette valley sleeping in quiet beauty lying at their feet. The broad silver belt of the Columbia winds through the evergreen valley toward the ocean. Within these limits is every variety of mountain and valley, lake and prairie, bold beetling precipices and graceful rounded summits blending and melting away into each other. It was with reluctance that at length we took the first step down the declivity.

The descent to the great crevasse, though much more rapidly accomplished, was quite as perilous as the ascent from it. We were now approaching the gorge, and a mis-step might precipitate us into unfathomed depths. Less than half an hour was sufficient to retrace the weary climbing of two hours, and standing for a moment on the upper edge of the chasm, I bounded over it where it was 8 feet wide. The impetus of the leap sent me sliding a long distance down the icy steep below.

In two hours and a half from the summit we were in our camp. * * *

3. *Meeting of the National Academy of Sciences in January*, 1867.—At the meeting of the National Academy held in the capitol at Washington in January last, commencing with the 23d of the month, the following papers were presented:

(1.) Report on the galvanic action from the association of zinc and iron by a COMMITTEE OF THE ACADEMY.

(2.) Report on the deterioration and means of improving Greytown Harbor, Nicaragua, by a COMMITTEE OF THE ACADEMY.

(3.) Report on proving and gauging spirits subject to duties, by a COMMITTEE OF THE ACADEMY.

(4.) On some of the phenomena presented by the planet Venus when near to her inferior conjunction, by S. ALEXANDER.

(5.) On the longitude between Europe and America and the velocity of galvanic signals in the Atlantic Cable, by B. A. GOULD.

(6.) On the principles of the classification of fishes, by L. AGASSIZ.

(7.) Recent observations on the Glacial Phenomena of the Basin of the Great Lakes, by J. S. NEWBERRY.

4. *Library and Geological specimens of Prof. H. D. Rogers.*—At a meeting of the Massachusetts Institute of Technology last December, the scientific library and the collection of geological specimens of the late Prof. Henry D. Rogers of the University of Glasgow, were presented to the Institute.

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VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *A Manual of Inorganic Chemistry arranged to facilitate the experimental demonstration of the Facts and Principles of the Science;* by CHARLES W. ELIOT, Professor of Analytical Chemistry and Metallurgy, and FRANK H. STORER, Professor of General and Industrial Chemistry in the Massachusetts Institute of Technology. Boston. Printed for the authors. 1867.—We have received advance sheets of a good portion of this work, which will be completed in June. A careful examination of the 420 pages before us leads us to believe that the book will greatly contribute to extend the study of chemistry in this country. There are comparatively few students who can easily master chemistry under the system of teaching that now prevails. It is, on the one hand, impossible to make rapid progress in the acquisition of the facts of the science without a knowledge of principles; and on the other hand, principles cannot take a firm hold in the mind except as demonstrated by facts. The true method of teaching chemistry is in imitation of the process by which the science has been created, and this is primarily one of experiment and induction.

The beginner may naturally and easily put himself in the condition of an inquirer, but it is only by efforts that would exhaust and dishearten most young learners who have not naturally a special fondness for the science, that he can regard the subject from the standpoint of the sage. In the book under notice, the authors open with a brief introduction of four pages, in which the objects and scope of chemistry are concisely defined. Then they enter at once upon the consideration of the science itself, not by laying down a tedious series of general propositions or by toiling over notations, nomenclatures, and classifications, but by an account of common phenomena which are analyzed after the natural method. A few simple experiments open the way to the study of air and of its elements, of water and its ingredients. Following these, the compounds of these elements with each other, viz., the oxyds of nitrogen and ammonia, are discussed. By means of simple experiments the facts of definite combination by weight and volume are brought out, and following these demonstrations, on page 27, the discussion of atoms and molecules is introduced. In similar manner notation, typical and dualistic formulæ, dissociation, homologous series, and the most important considerations of chemical physics are introduced in their appropriate places.

The work is admirably adapted for the present transition state of the science. While not rejecting the established modes of expression in which the literature of chemistry is chiefly to be found, it presents, in our opinion, fully as much of the newer views as are appropriate to an elementary work. The student who has mastered this treatise is fitted thereby to study with profit and zest the writings of Wurtz, Kekule, Odling, Hofmann, and Frankland.

The adaptation to experimental teaching meets a want which has been pressingly felt, and should ensure the establishment of new working laboratories in our higher schools, as well as the practical drilling of a much larger number of students in those now in operation. The experiments, more than 200 in number, are all well described and easy of exe-

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cution with a comparatively small outlay for materials. They are intended to be repeated by the students themselves under proper direction, and this mode of instruction which engages and disciplines the perceptive faculties and unfolds the methods of investigation is one which is more and more coming to be regarded as essential to a successful system of education.

The book is not only excellently adapted for the instruction of beginners, but, as far as its size admits, reflects very satisfactorily the present state of the science. It is entirely free from the puerilities, the blunders, and the contradictions which are so prominent in the majority of our elementary text-books. S. W. J.

2. *Traité des Matières Colorantes, comprenant leurs applications à la Teinture et à l'Impression, et des notices sur les fibres Textiles, les Epaississants, et les Mordants;* publié sous les auspices de la Société Industrielle de Mulhouse et avec le concours de son Comité de Chimie. Par M. P. SCHUTZENBERGER, Docteur, &c. Paris. (Victor Masson et Fils.) 2 vols. 8vo, avec figures et échantillons intercalés dans le texte.—Though many books have been published on dyeing and printing, there has long been a want of some sound, comprehensive work representing the present state of knowledge respecting these arts. The great work of Persoz, Traité de l'Impression des Tissus, may still be considered as the only full, standard treatise on the subject, but its publication dates so far back that it would require at least a whole volume of *addenda* to bring it forward to the present date. The last twenty years have added something to our knowledge of natural dyes, while most of the numerous artificial colors have been discovered within this period. Many changes have been made in the mixtures used in printing, and new plans have come into use for the subsequent operations. Thus the "aging box" is now made to shorten materially the time required for "aging" goods printed in the "madder style." The aniline colors have made an immense addition to the resources of the dyer and printer. Yet the world has been growing all the while, and these colors have found room for themselves without wholly displacing other things. As gunpowder still holds its own in spite of the extravagant prophecies about gun-cotton, so the enthusiastic hopes of some noted chemists respecting artificial dyes are very far from being realized. It is likely to be a long time before the coal mines of England will supply all the world with all needed dyes. Indigo, cochineal, and madder have lost little of their importance, the colors derived from lichens are still in use, and even carthamus has something more than a historic value.

What is lacking in the older works on dyestuffs is, in a great measure, supplied by the treatise now before us. The author says of the part which he has assigned to himself:—"Le but principal de cet ouvrage est donc la description des matières tinctoriales au point de vue de leurs propriétés chimiques, de leur préparation, et des moyens de determiner leur pureté et leur richesse." He writes not as a compiler making a book out of an indigested mass of clippings from other books, but as one who is himself an investigator, as one who has something fresh to say and knows how to say it in proper compass. In fact he comes up to our expectations of one living at a great industrial center and having the

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opportunities, the qualifications, and the rare assistance thus set forth in the preface :—" Onze années passées à Mulhouse comme professeur de chimie pure et appliquée, et comme directeur d'un laboratoire d'enseignment pratique, n'ont permis de réunir les éléments de ce traité. La Société Industrielle, toujours prête à fixer son attention sur tout ce qui est réellement utile, a bien voulu s'interesser au projet de ce travail, et m'offrir le concours effectif de ses lumières. La plupart des articles du premier volume et une partie de ceux du second ont été lus et discutés en séance du Comité de chimie."

We rejoice that it is no longer necessary to plead total ignorance when asked to recommend good, live books on tinctorial science and art. The technological student and the enlightened practical man may here find a really standard, recent work on the subject. It is true that the scientific novice might desire more, and more particular information on some points. Thus the so-called arseniate, silicate, and stannate of soda figure largely in practical printing, and yet one may search books long and almost in vain to find any tolerable account of their actual composition and mode of manufacture. If we examine the articles in the market that work best, we find that the arseniate is not the salt known to chemists by that name, but an anhydrous arseniate neutral to litmus and containing three equivalents of soda to two equivalents of arsenic acid; that the silicate is not the normal salt, but an indefinite waterglass combining one equivalent of soda with from two to three equivalents of silica; that the stannate contains a considerable excess of caustic alkali. For want of accurate knowledge on this last matter, a large establishment that we know of formerly lost several thousand dollars a year by persevering in a vicious mode of manufacturing the stannate, whereby only one-half of the tin used was obtained in solution.

Mr. Schutzenberger passes by the more common chemicals even more hastily than many other writers. But it is some compensation that he thereby gains the more room for other interesting and somewhat novel matter. He dwells much more fully than usual on the fact that such substances as hematin, quercitrin, and brazilin exist in nature as easily soluble glucosids, and not as the disengaged products always described in the books as very slightly soluble in cold water; and so the student will no longer be puzzled to understand why a decoction of logwood or Lima wood may be concentrated to a high degree without depositing the coloring matter. Though each one may find more conciseness on some points than he could have desired, we think on the whole the work will prove to all uncommonly full and satisfactory. J. M. O.

3. *Descriptive Astronomy;* by GEORGE F. CHAMBERS, F.R.A.S. (Clarendon Press Series). Macmillan & Co., London, 1867. 8vo, pp. xl, and 816.—The aim of the writer, who is an amateur astronomer, was to prepare a work that at one and the same time should be attractive to the general reader, serviceable to the student, and handy for purposes of reference to the professional astronomer. Especial pains were taken to present the latest information on all branches of the science.

The work is profusely illustrated, and thus is made quite attractive for popular reading. Notwithstanding the great difficulty of representing such delicate objects as comets and nebulæ by wood-cuts, the artists

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and publishers have succeeded remarkably well. The author does not encroach upon the domain of physical and practical astronomy by the use of formulas, as he seems to have most carefully avoided them. For a large class of readers the work would be thus no doubt much more desirable. This is made up to the professional astronomer by the multitude of tables, references, constants, &c., with which the book is crowded. Every person who owns or uses a telescope should have this work. We would call special attention to the chapters on comets, clusters and nebulæ, and celestial photography, and also to the catalogue of celestial objects available for small telescopes. Being prepared by a practical astronomer, he has in general given just that information which is convenient in the observatory. The three chapters on Meteoric Astronomy are, however, unworthy of a place in the book.

4. *Études et Lectures sur l'Astronomie*, par CAMILLE FLAMMARION. Tome I. 18mo, pp. 262. Paris, 1867. (Gauthier-Villars.)—This is a collection of several very interesting articles, written originally for the Cosmos and the Revue Contemporaine, giving the recent progress of astronomical science. The principal subjects are, the Nature and Physical Constitution of the Sun, the Minor Planets, Comets, Eclipses, Terrestrial Magnetism, Shooting Stars, the Nebula and Cosmogony. At the end of the volume is a celestial chart giving the apparent paths of the planets during the year 1867, a device which we heartily commend to almanac makers.

5. *Weights and Measures according to the Decimal System, with tables of conversion for Commercial and Scientific uses;* by B. F. CRAIG, M.D. 48 pp., 16mo. New York, 1867. (D. Van Nostrand.)—A convenient and handsomely printed little manual intended to aid in converting the common weights and measures into those of the French or decimal system and vice versa. The values are given up to 9 multiples, first of the different English weights and measures, with the corresponding values in the decimal system; and then of the decimal weights and measures with the corresponding values in the English weights and measures.

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THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. I.—*On Perfect Harmony in Music, the Double Diatonic Scale, and an Enharmonic Key-Board for Organs, Piano-fortes, etc.;* by HENRY WARD POOLE, of South Danvers, Mass.

1. SEVENTEEN years ago I published in this Journal* a theory of Perfect Intonation in music, with a description of an organ made to obtain this result, which had then just been completed. The organ was provided with pedals and mechanism by which the large number of pipes necessary for perfect tuning could be played by the common key-board. It was supposed that all music, for the moment, was in some key or scale. This scale the organist could prepare by putting down a single pedal, which had the effect of uniting the twelve finger-keys of each octave with twelve valves, and disconnecting all the others. As the music passed into other scales, by modulation, and other less marked transitions, the player, by touching the pedal of the new scale, made the changes of sounds required. In the present paper, I shall describe a new key-board in which all the sounds contained in the organ are represented, and placed within control of the organist, without aid from pedals or any interior mechanism; and which is practicable for any extent of modulation, or number of notes in the octave. It is uniform in all keys, and the same succession of melodies or harmonies is fingered the same in every signature. The pedal-base is also provided for by an appropriate key-board. I shall also treat of the scale heretofore unnoticed by theorists, to which I have given the name of *Double Diatonic*,† together with other matters bearing upon the theory and practice of perfect harmony.

* Vol. ix, Jan., Mar., 1850. † See the Mathematical Monthly, ii, 16, 1859.

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2. In my former article in this Journal it was maintained that the Prime Seventh with the ratio 4 : 7 was harmonious, admissible and used in music, although this, so far as I have seen, was asserted for the first time.* It is clearly evident that this element enters into music of all kinds, and that the diatonic scale must contain it, or that there must be *two* diatonic scales: which latter supposition is most correct. If only fifths and thirds are admitted in forming a diatonic scale it will naturally be made of the common chords of three roots, namely, the tonic or key-note, the dominant or fifth above, and the subdominant or fifth below. This I have distinguished as the *triple diatonic scale*, which has three intervals in the ratio of 8 : 9, 9 : 10, and 15 : 16. The notes are represented by the syllables Do, Re, Mi, etc., which always bear the same relation to the key-note and to each other. Thus, Do to Re is always as 8 : 9 or a major tone, Re to Mi as 9 : 10 or a minor tone, Mi to Fa as 15 : 16 or a diatonic semitone. No exception is admitted in this rule. Considering the key-note to make 48 vibrations in a given time, we have the

TRIPLE DIATONIC SCALE. DO to DO.

Common chords on Do, Sol *and* Fa.

	Do	Re	Mi	Fa	Sol	La	Si	Do
Rel. vibrations,	48	54	60	64	72	80	90	96
	First.	Second.	Third.	Fourth.	Fifth.	Sixth	Seventh.	Octave.
Intervals,	8 : 9	9 : 10	15 : 16	8 : 9	9 : 10	8 : 9	15 : 16	

3. But if the ear prefers—and it often does prefer—the subdominant harmony may be suppressed, and the fourth of the scale, Fa, and the sixth, La, may be replaced by the perfect seventh and ninth of the dominant harmony; so that if we still take *Do* as a starting point or first of the scale, we require a *new Fa* and *La*, for which formerly there have been no names. But the perfect seventh, or *flat seventh* as it is called, is already in solmization sung as Si^b, taking the sound of *Se*—pronounced by the Italian rules as are all these syllables, and like the English *Say*—and no other name is needed. Below *Si* therefore we take *Se*, and take as first of a scale the *Fa* already given. Then we have the

DOUBLE DIATONIC SCALE. FA to FA.

Common chord on Fa, *chord of* 7 *and* 9 *on* Do.

	Fa	Sol	La	Se	Do	Re	Mi	Fa
Rel. vibrations,	32	36	40	42	48	54	60	64
or	48	54	60	63	72	81	90	96
	First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Octave.
Intervals,	8 : 9	9 : 10	20 : 21	7 : 8	8 : 9	9 : 10	15 : 16	

* The German "Jahrbuch" of Liebig and Kopp, in a discriminating review of my article in this Journal in 1850, specified this declaration.

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4. The reasons for taking the key-note on *Fa* will appear on consideration, but for the present the reader will recollect that if the flat seventh of the natural key is taken—for example B^b with the common chord of C—the ear requires a resolution on the chord of F or *Fa*, which is the controlling note.

5. To sing this scale is easy, provided the intervals of the triple scale are well fixed by their syllables; and it only remains to learn the intervals *La* to *Se*, 20 : 21, and *Se* to *Do*, 7 : 8, which are easily recognized on hearing the harmony which should accompany a lesson in singing. In the last scale are five different intervals in place of the three of the first scale, by which more variety is secured.

6. These two scales contain all that belongs to the major keys; the additional notes required to complete the minor keys will be considered afterwards, as well as those called "accidentals," which are borrowed from related scales. The notation generally employed in music is practically correct, and, without changing the letters or sharps and flats, scales may be noted so that the exact sounds shall be indicated. In all times a singer must know or *feel* the pitch of each note, if he would sing it correctly. If he has learned the intervals by solmization, in the only rational way, or by always giving the same intervals to the same succession of syllables, and if he knows by the written music what intervals are called for, he will give them equally well in the key of C or in C♯, or on the dozen different pitches which can be given between these two sounds. But when we are to deal with fixed sounds, as is necessary when constructing an instrument, or when two fixed instruments may have to play together, it is necessary to know and express the exact sounds required. If the note be C, it will not do to use that which is the key-note of the natural scale for the third of four flats, which is a comma lower, nor for the perfect seventh of D, two sharps, which is lower still. I formerly indicated this distinction by a numerical index, but the following system presents advantages.

7. Every key-note is marked as usual, but with a Roman capital; every major third to these key-notes with Roman lower case, and every perfect seventh with a Gothic capital. The second, fourth and fifth of the triple diatonic scale, being key-notes in other scales, and in the series of key-notes, each a fifth one from another, are accordingly in Roman capitals. So the sixth and seventh of the same scale are thirds of other keys, and marked in letters of the lower case. The two diatonic scales will then be represented thus in the natural key.

Triple diatonic,	C	D	e	F	G	a	b	C
	Do	Re	mi	Fa	Sol	la	si	Do
Double diatonic,	C	D	e	F	G	A	b	C
	Fa	Sol	la	**se**	Do	Re	mi	Fa

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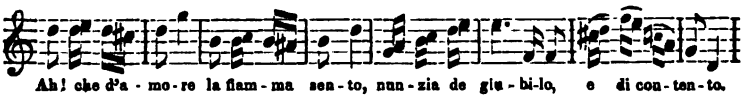
8. Much that is curious and interesting concerning this double diatonic scale could be shown, did the character of this article admit, and were it practicable to give musical examples from the masters. It would be seen that the most beautiful, varied and ornate compositions are made from the elements it contains. It has the capacity in certain styles of music of using with much grace accidentals, or chromatics, as they are called; for example, the *si*, the regular leading note to *Do*, and the *Sol*♯, diatonic semitone below *la*, or the leading note to the relative minor; these chromatics always ascending diatonic semitone (15 : 16) to the notes above. Especially is the *si*, or major seventh, used with *Do*, making the ratio of 8 : 15, if it is to be considered as claiming to be attended to as concordant, or as otherwise than as a passing note of a melody. But when perfectly tuned it is heard in harmony, especially with the *mi* and *Sol* with which it is sounded. An example will be given to illustrate this. First, it may be mentioned that besides the three series of notes—key-notes, thirds and sevenths—another series is used, that of the dominant's thirds in the minor scales, the leading notes to the relative minor's key-note. This in each key is *Sol*♯, and is tuned a major third above *mi;* and *mi*, *Sol*♯ and *si* form a major common chord (4 : 5 : 6). These notes are expressed in italic letters of the lower-case. The example being the double diatonic scale of G, in one sharp, I shall give this scale with the accidentals introduced in the following melody from Rossini's 'Il Barbiere di Seviglia.' The air will be remembered as appearing in the accompaniment to the song or recitative (for it is all on one note, D or Do, the part which this accompanies), in which Figaro describes his place of business, (*Numero quindici*, etc.), and afterward is the air sung by Almaviva when he has a prospect of seeing Rosina, while at the same time Figaro sings in joy at the sound of his patron's gold.

DOUBLE DIATONIC SCALE IN G, WITH ACCIDENTALS.

G	A	a♯	b	C	c♯	D	E	f♯	G
FA	SOL	(sol♯)	la	SO	(si)	Do	RE	mi	FA

Almaviva sings



Harmony of the accompaniment.

G - - - - - - - - - - - - - - - - - D with the 7th - - G

9. Although it is convenient to consider a special strain of music as being in a definite key or scale, and to consider the notes which are sometimes prone to introduce themselves as "accidentals," and in a manner extraneous, yet the truth is that

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all such intruders have the excuse of being relatives, with the right of entrance, under certain rules, which the great masters understand. Among the related notes in the scale in G, last given, are C and e, or the fourth and sixth of the double diatonic on the same key-note, G. These are introduced in a passing manner, as in the cadence—a familiar example is found in the *Oh! dolce concento** of Mozart—where the subdominant harmony, not before heard, comes in just before the final dominant and tonic chords. In the example given from Rossini, the third note of the third measure may be C, as well as c—*Fa* of the triple scale, as well as *Se* of the double. In the fifth measure the fourth note may be the same C, and the sixth note may be e, the sixth or *la* of the triple scale of G. But the following note on the same degree in the sixth measure is clearly and necessarily E, Re, or the ninth of the chord of the seventh on D. So the third note of the first measure may be e. The enharmonic change from e to E, a rise of a comma, is often required, is very beautiful, and I have proved that it can readily be made for my singers, who know this change of a comma as well as others know the tone or semitone, will give it, even without accompaniment, with perfect accuracy, as proved by the harmony afterward applied as a test. All this variety within the limits of musical laws—which only forbid what is disorderly, complicated, or what the ear will not distinguish—adds to the pleasure of music, and it is the exact rendering of all the melodies and harmonies which gives the charm to a good singer. When acutely perceptive of such accuracy, I had the good fortune to listen to Alboni on all the occasions when it was possible to do so. I thought her then, and still am of the opinion, that she was the best singer I have ever heard. It is certain that she had a wonderful exactness in executing whatever she undertook. There was no "temperament" in *her* scales, and what the strictest theory requires in intonation she understood and gave. She sang music whose analysis would alarm a student with its apparent difficulties; but the delighted auditors perceived only a delicious and "easy" flow of melody.

10. Fortunately, the greater part of the difficulties in the higher class of melodies are overcome by the unconscious or instinctive talent of the singers. The accompaniment of such melodies is not difficult, and the harmonies attending make clear what the melody must be. No instrument will ever compete with the voice in its peculiar department, but may surpass it in that which it is fitted for. Neither voices nor instruments separately can produce the highest effects in music; those will be attained by the combination of the two. Improvement in the

* Generally so called. It is the air in Mozart's *Il Flauto Magico*, "*Oh! cara armonia.*" From this is taken the song "Away with melancholy."

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instruments which accompany will be followed by better vocal music.

11. For understanding what is to follow, I would have it borne in mind, that I consider that all musical ratios derived from the primes 3, 5, and 7 are appreciable by the ear, and may be used in all their combinations and transpositions into different keys, which is already done in a series of perfect fifths. The next prime, the eleventh, does not present sufficient claims to be admitted to the musical canon, except under regulations which as yet I would not undertake to define. I can tune it, and can perceive that it yields harmony so far as to give coincidences in its vibrations with the other prime chords, the fifth, the third and the seventh. It is not impossible, when a great refinement is made in music, and the sense highly cultivated, that this class of novel sounds may be introduced and appreciated. But except under such conditions, and without the most exact intonation, the eleventh would fail to give any effect other than incomprehensible discord. It might be admissible in the harmonic stops of an organ—those called mixtures, sesquialtras, etc.—but only under a system of perfect harmony.

12. For a practical instrument I would provide five series of sounds—a series signifying that each sound is a fifth from that which precedes, and that which follows it. These five series, arranged in the order of their importance, are as follows, the notes of each series being marked with the letter and sharp or flat in common use, but in a distinctive type for each series:

Series I.	Key-Notes.	Roman capitals, A, B.
" II.	Thirds (major) to key-notes, series I,	Roman lower-case, a, b.
" III.	Perfect sevenths to key-notes, " I,	Gothic capitals, **A**, **B**.
	(These constitute the major scales.)	
" IV.	Dominant thirds (major), in the minor mode, being major thirds to II,	Italic lower-case, *a*, *b*.
" V.	Dominant sevenths, in the minor mode, being perfect sevenths to II,	Gothic lower-case, **a**, **b**.
	(These two last complete the minor mode.)	

13. This being understood, it will be known that the same letter in the same type is always the same sound, and its relation evident; that the same letter in Roman lower-case is a comma lower than the same in capitals, and a quarter (0·256) of a comma higher than the seventh in Gothic capitals. A letter of the III series, in Italics, is two commas below the same in the I series, or one comma below that of the II. The sevenths of the V are one comma below those of the III; the lower-case letter indicating this difference below the capital.

14. Among the names which have to be remembered as advocates of perfect harmony and just ideas in music, perhaps the first in modern times is that of Gen. T. Perronet Thompson of

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London. My first knowledge of his valuable services came during the preparation of the second part of my article in this Journal (in March, 1850), by an allusion in the Westminster Review to an enharmonic organ which he had just brought out in London. This led to the reading of his spirited articles on music and other subjects in the Westminster Review, and to the seeking his acquaintance, which, through a considerable correspondence, I have had the good fortune to make. I have also received his "*Theory and Practice of Just Intonation*" and "*Description and use of the Enharmonic Organ*" of his invention, "*built for the Exhibition of* 1851, *and an Appendix tracing the identity of design with the Enharmonic of the Ancients.* London, 1850." 8vo. I also obtained, after much search, and by the kind efforts of the author, what appears to be the initiative work of Gen. Thompson in musical doctrines. Although a work requiring thorough classical and mathematical knowledge, as well as information in several departments of literature and taste, it bears the modest title, "*Instructions to my Daughter for Playing on the Enharmonic Guitar, being an attempt to effect the execution of correct harmony, on principles analogous to those of the ancient Enharmonic. By a Member of the University of Cambridge. London*, 1829." In folio, with illustrations. This work seems to have been stimulated by a fine perception of the delicate harmonies of which the guitar strings are capable, and by falling upon the collection of the "Seven Ancient Greek authors on Music," collected and published by Meibomius, and printed on the Elzevir press in 1652, a copy of which is in the library of Harvard College. The Euclid of geometry is one of these seven, and there is an eighth author who is not reckoned an ancient, as he lived as late as A.D. 470. It is clear that there was something which these called "*enharmonic*," which is declared to be the "*most accurate.*" (Aristides Quintilianus, lib. i, p. 19, ed. Meib.) That "the name of enharmonic [or harmony] is given to the genus abounding in the smallest intervals; from the harmonizing." (Idem, i, 18.) "The enharmonic, so called from being taken in the perfect intervalling of whatever is subjected to harmony." (Id., ii, 111.) With much more to justify Gen. Thompson in adopting the title of Enharmonic: which name I also take as appropriate to a system of perfect harmony, and to the instruments which are constructed on its principles.

15. The enharmonic organ of Gen. Thompson had key-boards in which, without any change in the interior of the organ, all sounds contained therein could be given. Every sound of the organ was represented in three key-boards, except some very rarely called for, which had exchangeable pipes. The organ of Mr. Alley and myself had a key-board like that of the common organs, and the fingering was the same: all changes were made

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by pedals, one for each key, which put the organ in tune for its own scales. It could be played without the player knowing what sounds he used—he only needed to keep the organ in the right key. Gen. Thompson justly remarks that his system would have merits over ours, in compelling a musician to know what he is doing. But in the dark days of enharmonic science it may be excusable not to demand too much of the organists.

16. There are great difficulties which present themselves in admitting to a key-board the multitude of sounds required if several transpositions or signatures are to be played in. If the five series of sounds already described, § 12, are carried into the keys from nine flats to nine sharps—nineteen signatures—just one hundred notes to the octave are required! But an octave is limited in width by the span of the fingers. Six and a half inches is about the convenient average measure, and this is adopted by organ and piano-forte makers. If the notes we want are divided equally into this space each will get the hundredth part of it, or sixty-five thousandths of an inch. The pins of a barrel organ might play upon them, but with human fingers it is hardly possible.

17. But there is a fortunate circumstance in the relation of the sounds which comes to our aid. All are not wanted at the same time; when we are near the key of nine sharps there is no possibility of our requiring the notes of nine flats. These we may arrange therefore at a distance front or back, and place near by the related notes which may be required in connection with those already in use.

18. At least seven finger-keys should be in convenient relation to each other, and of sufficient size and position to allow of their being touched, and for the changes of fingers necessary in running scales and taking chords in different positions. Such a key-board I have endeavored to devise, the result of which may be seen from the following description and figures.*

19. The first point I took in the resolution of the problem was, the convenience of the broad white ivory keys of the common key-board, and the elevated black keys—the white especially affording room for shifting the fingers, and the raised keys making it easy to touch a narrow key, which it would be hard to do if all were in one level. The second: that the key-notes and the thirds, being of different classes, might be assigned to these two classes of finger-keys, naturally giving to the first class the more extended keys, or the white. So the octave ought to have its seven notes. Pieces of bristol board were cut to the width of the common white keys, or nearly an inch, and in length double that of the part in front of the black keys.

* At the time of writing (April, 1867) I have made application for a patent for this key-board.

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With the same material I made elevated black keys of the width and height of those of the common key-board, and of the length of 2·7 inches, which were arranged in hopes of getting at least the diatonic scales, triple and double, which could be easily managed, and in a manner uniform for all keys.

20. This provisional key-board is not figured here, but may be understood by reference to figs. 1, 2 and 3, which contain also the additional series of sounds, IV and V, § 12. In fig. 1 let the black key, d, be moved to the left until its left edge coincides with the right edge of C, its back end as now being in contact with the front end of the white key D; let e, f♯, and the two keys (F' and another not marked but really E♭') marked with vertical lines indicating their color, red, be moved in the same direction and distance as d, till they are in contact, respectively, with D and E. There is no room now for *d*♯ and d' and their two companions by f♯, but we have all the key-notes, thirds and perfect sevenths, and the advantage of greater width in the white keys, which are nearly an inch and a quarter wide (1·21 in., the black keys being 0·45). This key-board, although deficient in the minor mode, from the absence of the series IV and V, is still recommendable where economy is necessary, as all the music of the major key, including the beautiful chord of the seventh, can be played; except in cases where certain accidentals are introduced from the minor mode, as illustrated in the example from Rossini in § 8.

21. A portion of the complete enharmonic key-board is shown in perspective in fig. 1, in the natural size—the length of the keys being reduced to one-half by the perspective. The keys are of five different colors—represented here, the white and black by their natural colors, and the rest according to heraldic rules, viz., the *red* by vertical lines, the *blue* by horizontal, and the *yellow* by white stippled with black—and of as many different elevations. The following table represents this.

Series.	Color.	Elevation.	Example.
I. Key-notes,	white	0·0	C, D
II. Thirds,	black	0·4 in.	b, e
III. Sevenths,	red	0·05 "	F'
IV. Dom. 3ds, minor,	blue	0·10 "	*d*♯
V. Dom. 7ths, minor,	yellow	0·15 "	d'

22. These keys all have vertical rectilinear motion so that a touch on any part of their surface produces always the same effect. This is attained—in one method—by attaching each to a pair of guiding rods, passing down through a couple of horizontal tables where they are secured to a piece which communi-

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cates in the usual manner with the valves or hammers. It will be understood that the mechanical construction of the instrument beyond the key-board may be the same as usual, except that its *number* of pipes or strings must be multiplied.

23. As the assemblage of all the notes may confuse the eye at first sight, I have drawn on half scale the plan of the finger-keys which in *every signature*—or commencing on any white key whatever—give the triple and double diatonic scales. The white keys are of the width of 0·993 in., the black keys having the width of 0·45.* The white keys on the common key-board are but 0·93, or the seventh of 6½ inches. The plan in fig. 2 will enable a player to judge whether the scale can be executed. It is immediately intelligible even to a child, who, having learned the order in one key, knows it in every other. The keys are considered by their relations to each other, that is, as Do, Re, etc., and (to repeat it again), Do may be taken on any white key. The fingering in the triple diatonic scale is the same as in that of the natural key, and of others, on the common key-board, and the fingers easily reach the keys and change on Fa and Do as in the latter case. In the following scales the usual signs represent the thumb and four fingers; see fig. 2.

TRIPLE DIATONIC SCALE—*Its fingering.*

Do	Re	mi	Fa	Sol	la	si	Do
+	1	2	+	1	2	3	4 (or +)

DOUBLE DIATONIC SCALE—*Its fingering.*

Fa	Sol	la	Se	Do	Re	mi	Fa
+	1	2	3	+	1	2	3

The player is recommended to complete the octave, Fa to Fa, by copying the four lower keys, Do, Re, mi, Fa, figs. 2, 3, and placing the lower Do upon the upper one, or by conceiving that this has been done. This will show the double scale in its regular order.

24. I regret that the limits of these pages did not allow a larger portion of the key-board, and permit reference to it in the manner of taking the several chords in their various positions. But I think that those interested can extend the diagrams by the data given, and I shall, therefore, give the fingering for several chords, which being understood in one key will be the same in all transpositions.

* The widths are established thus: first determine the width of the octave, and that of the black keys. Representing these respectively by O, and b, the width of the white key (W), is obtained thus: $\frac{O+b}{7}=W$. For the key-board for major keys, only, § 20, the formula is $\frac{O-b}{6}=W$.

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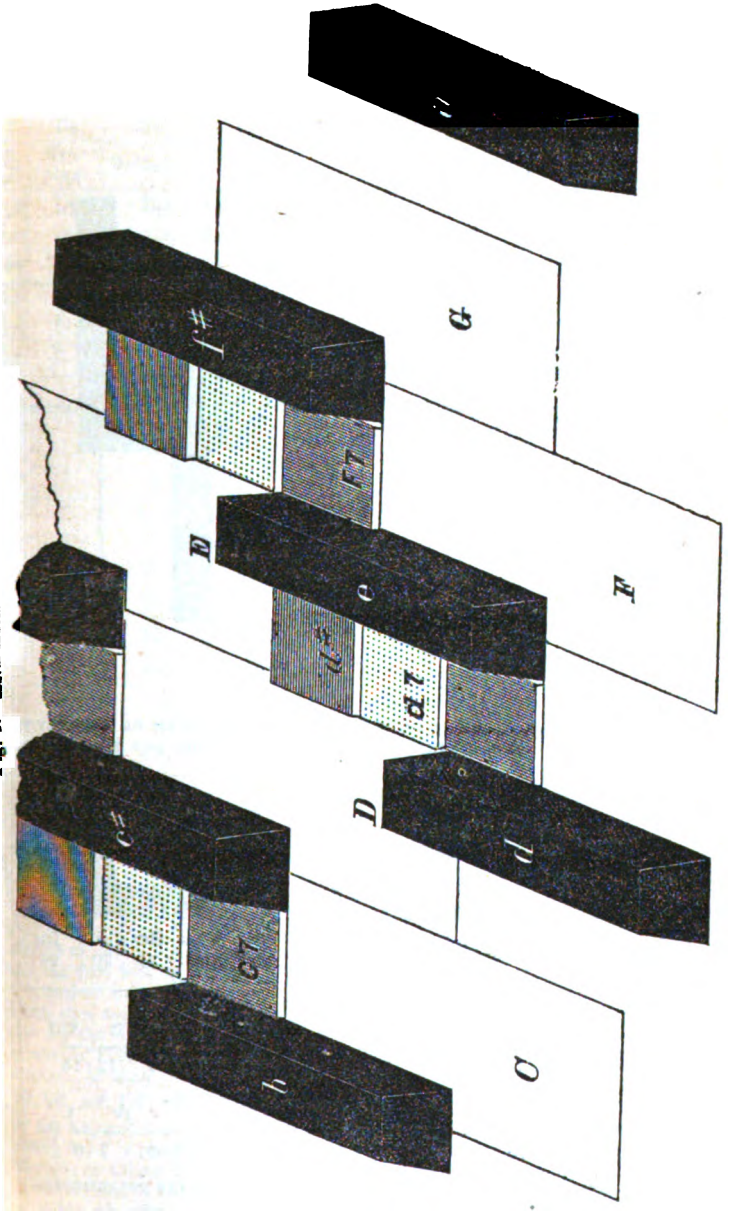

Fig. 1.—ENHARMONIC KEY-BOARD.

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Fig. 2.—A portion of the Enharmonic Key-board, showing the relative position of the Finger-keys which give the Triple and Double Diatonic Scales in every key or signature, or taking Do on any white key.—*Scale of one-half.*

The white and black keys are represented in their natural colors; the red keys—perfect sevenths—by vertical lines; the blue keys—dominant thirds in the minor mode—by horizontal lines; the yellow keys—dominant sevenths in the minor mode—by white stippled with black.

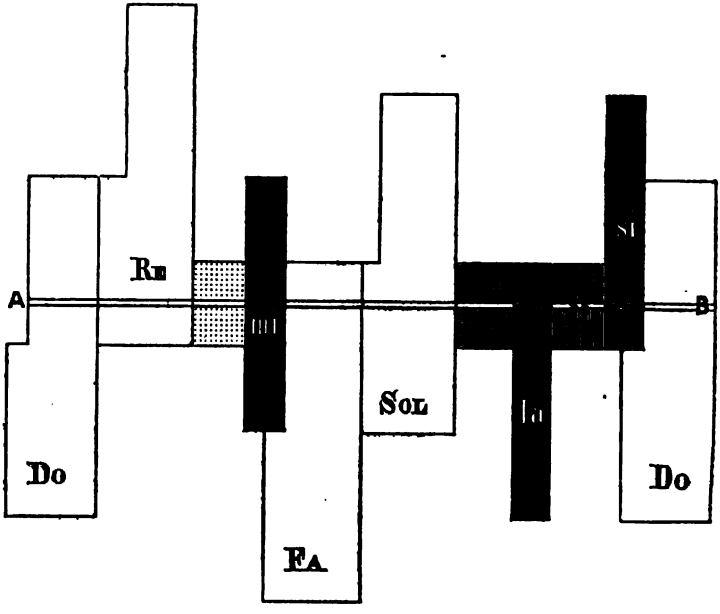

Fig. 3.—Section through A B, or the third quarter of any key-note, exposing all the notes of that key both in the Major and Minor modes.

Do	Re	Dom.7 R.Min.	mi	Fa	Sol	Dom.3 R.Min.	la	Se	si	Do
48	54	52·5	60	64	72	75	80	84	90	96

TRIPLE DIATONIC SCALE.

I	II	III	IV	V	VI	VII	VIII
8 : 9	9 : 10	15 : 16	8 : 9	9 : 10	8 : 9	15 : 16	

DOUBLE DIATONIC SCALE.

V	VI	VII	I	II	III	IV	V
8 : 9	9 : 10	15 : 16	8 : 9	9 : 10	20 : 21	7 : 8	

Sounds given by the above Finger-keys in the signatures corresponding.

1♯	G	A	a⁷	b	C	D	d♯	e	F⁷	f♯	G
II	C	D	d⁷	e	F	G	g♯	a	B♭⁷	b	C
1♭	F	G	g⁷	a	B♭	C	c♯	d	E♭⁷	e	F

A For extended Table see next page—Enharmonic Table. B

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ENHARMONIC TABLE,

COMPRISING THE NOTES GIVEN BY THE SECTION A B, FIGS. 2, 3, IN THE SIGNATURES FROM 9 FLATS TO 9 SHARPS, AND CONTAINING THEIR DIATONIC SCALES, INCLUDING THE MINOR MODE. 100 NOTES TO THE OCTAVE.*

Signature.	TRIPLE DIATONIC SCALE.										
	Do	Re		mi	Fa	Sol		la		si	Do
	Key-note.	Second.		3d.	Fourth	Fifth.		6th		7th.	Octave.
9♯	D♯	E♯	e♯⁷	f×	G♯	A♯	a×	b♯	C♯⁷	c×	D♯
8♯	G♯	A♯	a♯⁷	b♯	C♯	D♯	d×	e♯	F♯⁷	f×	G♯
7♯	C♯	D♯	d♯⁷	e♯	F♯	G♯	g×	a♯	B⁷	b♯	C♯
6♯	F♯	G♯	g♯⁷	a♯	B	C♯	c×	d♯	E⁷	e♯	F♯
5♯	B	C♯	c♯⁷	d♯	E	F♯	f×	g♯	A⁷	a♯	B
4♯	E	F♯	f♯⁷	g♯	A	B	b♯	c♯	D⁷	d♯	E
3♯	A	B	b⁷	c♯	D	E	e♯	f♯	G⁷	g♯	A
2♯	D	E	e⁷	f♯	G	A	a♯	b	C⁷	c♯	D
1♯	G	A	a⁷	b	C	D	d♯	e	F⁷	f♯	G
♮	C	D	d⁷	e	F	G	g♯	a	B♭⁷	b	C
1♭	F	G	g⁷	a	B♭	C	c♯	d	E♭⁷	e	F
2♭	B♭	C	c⁷	d	E♭	F	f♯	g	A♭⁷	a	B♭
3♭	E♭	F	f⁷	g	A♭	B♭	b	c	D♭⁷	d	E♭
4♭	A♭	B♭	b♭⁷	c	D♭	E♭	e	f	G♭⁷	g	A♭
5♭	D♭	E♭	e♭⁷	f	G♭	A♭	a	b♭	C♭⁷	c	D♭
6♭	G♭	A♭	a♭⁷	b♭	C♭	D♭	d	e♭	F♭⁷	f	G♭
7♭	C♭	D♭	d♭⁷	e♭	F♭	G♭	g	a♭	B♭♭⁷	b♭	C♭
8♭	F♭	G♭	g♭⁷	a♭	B♭♭	C♭	c	d♭	E♭♭⁷	e♭	F♭
9♭	B♭♭	C♭	c♭⁷	d♭	E♭♭	F♭	f	g♭	A♭♭⁷	a♭	B♭♭
	Fifth.	Sixth.		7th.	Key-note.	Second.		3rd	4th		Fifth.
	Do	Re		mi	Fa	Sol		la	Se		Do
	DOUBLE DIATONIC SCALE.										

* In considering the relation of the notes in the enharmonic system, there is constant reference to the series of fifths, and the following observation of their order may be of use. A descending series of fifths is a succession of the following letters, the first four of which form an English word, viz., *bead gcf*. When the series is extended down, a flat is added, always on the beginning of this series or on *b*, which sign continues without change to *f*, where another flat comes in, remaining also for the seven letters. If the series commences with one or more sharps, the same rule holds good, remembering that a sharped note is flatted by making it natural. If then we commence with B♯ we shall have

B♯, E♯, A♯, D♯, G♯, C♯, F♯—B, E, A, D, G, C, F—B♭, E♭, A♭, D♭, G♭, C♭, F♭, or the key-notes of the keys from twelve sharps to eight flats. Continuing, we should have a succession of the same letters, with double flats, ending with the key-note of fifteen flats; next the same with triple flats, leaving us in the unexplored regions of twenty-two flats, where for the present we will stop. The series of thirds, sevenths, etc., follow the same succession.

To the perfect sevenths is added the index ⁷, not as being essential, for the type alone is sufficient to distinguish them, but in order to make them more conspicuous at the present time.

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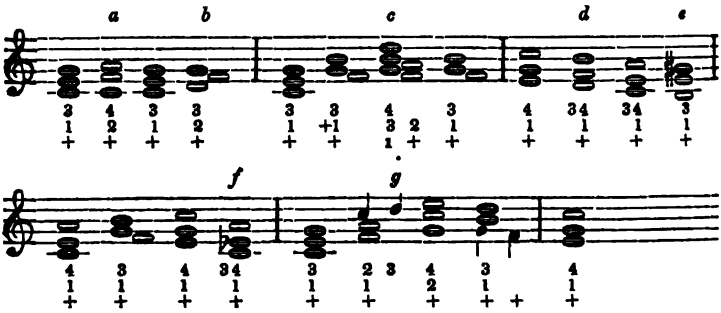
Examples in Fingering Chords on the Enharmonic Key-board.



NOTES.—*a*, subdominant chord, f and a; *b*, dominant with seventh, F^7; *c*, same with ninth, A; *d*, dominant seventh; *e*, dominant of relative minor; the seventh, d^7 may be added; *f*, subdominant with seventh; *g*, grave second d, or sixth of subdominant. The flattened note should be made natural in the next chord.

The double figures indicate that the key is touched with one finger, which is immediately changed for another, as is customary in passing smoothly from one chord to another. The base will be easily supplied by the musician, who will also observe the similarity between this fingering, and that of the common key-board.

25. The chords given belong in part to the triple, and in part to the double diatonic scales, or more properly speaking, those scales belong to these chords. For melodies originate from harmonies, if either can be said to generate the other, when both spring into existence almost at once. When Haydn, who from poverty could not obtain instruction in the theory of music, was forced to search for himself, he discovered certain rules which he was desired to impart. "Try to find them out," is understood to have been his sensible reply. It was supposed that they referred to the dependence of melody on harmony. However this may be, it is certain by the evidence contained in his compositions, that he had a very complete and delicate knowledge of the laws of harmony and their relation to melody, and that his inspiration came from a higher source than the tempered octave of twelve keys. The student who would follow Haydn's advice will find more aid in an enharmonic key-board with its pipes, strings, or even seraphine reeds, than in the most thorough primer of thorough-base that has yet been published. A pupil in harmony taught by an instrument tempered with twelve sounds is worse off than a student of mineralogy shut up with twelve specimens, or of chemistry with so many elementary substances. The latter might learn much that is true and important, and so might the musical student would he tune his twelve notes accurately to something. And I would not be understood as thinking that those thus taught harmony are totally ignorant of its true principles; I have met with notable instances where the truth was denied in words and declared in actions. Musi-

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cians sometimes learn by intuition, and contrary to what they are taught. So people are found just and amiable in spite of bad political or theological creeds and education.

26. Fig. 3 gives a section through the center of the third quarter of the key-note of fig. 2, and through all the notes, major and minor, of the signature to which it corresponds. The circumstance that a section in this place will cut all these notes and no others, might be considered remarkable and even wonderful, were it not for the fact that *this is the first principle on which the system is based.* In constructing the board a certain number of parallel spaces are laid down from left to right, and one space is assigned to each signature intended to be provided for. In the natural signature, C, the key-note, has its place of necessity. But C is the fourth of 1♯ and accordingly is prolonged backward,—toward what would be the top of a page or the north point of a map—over the space of 1♯. As it is the fifth of 1♭, and the second of 2♭, it is brought forward to cover the spaces of these two signatures also, and the whole key now is four times as long as the space originally assigned to each signature—which I have taken at nine-tenths of an inch, but which might have been more or less. So every other note wanted in a signature is placed here, and if wanted in adjoining ones it is protracted into them. Thus the e of the natural key is in all the spaces occupied by its root C, except in that of 2♭, where it is not used. The perfect sevenths and dominant thirds and sevenths of the minors being used each in one signature only, are not extended beyond it. Many simple rules for the relative position of the finger-keys could be given, which quickly fix their location in the mind, like the following:

27. *Rules.*—1. From the back half of a white key to the adjoining white key, on the right, is a *major tone*, 8 : 9, e. g., Do to Re, fig. 2, C to D, fig. 1, and *vice versâ.* 2. From the front half of a white key to the nearest black key, on the right, is a *minor tone*, 9 : 10; e. g., Re to mi, fig. 2, D to e, fig. 1, and *vice versâ.* 3. From the forward part of any black key to the adjoining white key into which it is half inserted, on the right, is a diatonic semitone, 15 : 16; e. g., mi to Fa, fig. 2, e to F, fig. 1, and *vice versâ.* 4. From the back end of any black key to the next black key on the right, is a *major tone;* e. g., la to si, fig. 2, e to f♯, fig. 1, and *vice versâ.* The distance to the right, or left, for whole tones is always the same, viz., the width of the white key or 0·993 in. Other rules will suggest themselves to the student, and these specimens will suffice.

28. The finger-keys supposed to be cut by the section A B, have their remaining portion in the rear, shown in perspective, and are marked with their names and the relative vibrations of their sounds. Below is indicated their order in the triple and

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double diatonic scales. Still below is a part of a table of the fixed notes which would be cut were this section made through the key-note of the several signatures indicated in the margin. The complete table should follow below this section, but as the space of the page does not allow, it is given entire on the opposite page, and should be referred to this section; even the width of the paper on which the sounds are marked corresponds with that of the finger-key in the place it is supposed to have been cut. This enharmonic table contains in its eleven columns all the notes of the major and minor modes, within the limits of nine flats to nine sharps, both inclusive, and comprises one hundred notes to the octave. Owing, however, to the close coincidence of two of the series with two others, twenty-two of these can be dispensed with without an error exceeding the hundredth of a comma in the fifths alone, and nothing elsewhere; which difference may be neglected, and is, practically, through the "sympathy" of accordant sounds, in perfect tune.

29. The last named circumstance is of much importance when the cost of organ-pipes is in question. Although there is no such thing in music as a "circle" of keys returning into itself theoretically and mathematically, yet there are certain close approximations which can be taken advantage of for economical reasons. If we ascend eight perfect fifths and a major third, and descend five octaves, we have a note higher than our starting pitch by something less than the eleventh of a comma, or in the relation of its vibrations to the starting pitch as 100,111 to 100,000. This supposes absolutely exact tuning, which is very difficult, as the pipes or strings, when near the sound they would give when sounded singly, draw into tune, and are perfectly accordant. So that if the tuner should make his fifths one-fiftieth of a comma flat—which he might do and have them all sounding in perfect tune—he would end as much below the starting pitch as perfect tuning should, theoretically, bring him above it. From which it is seen that he can, if he choose, flat each fifth one hundredth of comma and the two series will then coincide. Indeed, this distant note is useful as a landmark, and as a detective of small errors accumulating among so many fifths. It may be compared to the correction of measured distances by astronomical observations, without, like the latter, being subject to any errors of observation however small.

30. On reference to the table, page 13, two notes thus approximate are C in the natural key and b♯, the third of eight sharps. And the key-notes B♭♭, 9 flats, to G, 1 sharp, are thus available for the thirds, from a, in 1 flat to f×, in 9 sharps; in all eleven pipes saved. Also the thirds, d♭, in 9 flats, to b, in one sharp, are equally serviceable for the dominant thirds in the minor mode, c♯ in 1 flat to a× in 9 sharps, which include eleven more pipes, reducing the hundred of the table to seventy-eight only.

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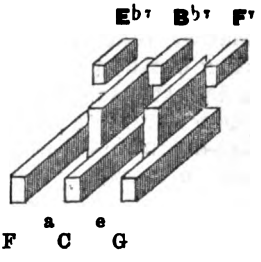
31. With the key-board that has been described, all the playing is done with the hands, without aid from the feet, and there is nothing to prevent the use of the feet for pedal bases. But the same key-board is not best for fingers and for feet, especially with the large number of its sounds, many of which are not called for in pedal bases, while others are constantly required. I have therefore devised an *enharmonic pedal key-board* which is sufficient and convenient for the pedal parts. The notes most needed are the key-notes. These are arranged in front in a straight line and in the order of the fifths ascending from left to right. Behind these and in a higher row and between the key-notes are the major thirds of the keys in front and to the left of each. Still above the thirds, and directly behind the key-notes, are the perfect sevenths of the latter. The key-notes are white, the thirds black, and the sevenths red, as in the manuals. Each pedal is an inch wide and two and a half inches from center to center apart. The arrangement of the notes in the three series is as in the fig. 4, and in the following sketch:

Fig. 4.—Enharmonic Pedal Key-board.



Order of the Pedal notes.

F♭⁷ C♭⁷ G♭⁷ D♭⁷ A♭⁷ E♭⁷ B♭⁷ F⁷ C⁷ G⁷ D⁷ A⁷ E⁷ B⁷
Sevenths.

b♭ f c g d a e b f♯ c♯ g♯ d♯ a♯
Thirds.

G♭ D♭ A♭ E♭ B♭ F C G D A E B F♯ C♯
Key-notes.

32. The most important notes of a pedal base, after the key-note, are the fifth above and below; these are found here on the right and left of the key-note. The third—in the second row—is on the right of its key-note, and the tonic of the relative minor on the left. So with the relative minor: its dominant is on its right as in the major scale. If a base requires the common chord in successive notes, or in *arpeggio*, they come easily thus (Ex. 1), the keys being all together. The chord of the seventh is taken thus (Ex. 2). The diatonic scales may be played in their melodic order, Do, Re, mi, etc., without having to skip farther than the second key above or below, or a distance of five inches. Further capabilities in this key-board will appear as it is studied.

Ex. 1.
mi
Do Sol
Ex. 2.
Se
mi
Do Sol

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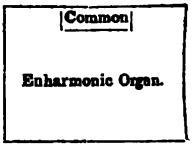
33. Consequently, there is equal facility as in the tempered organs for managing the pedals, for the swell organ, for bringing on and taking off the stops, etc. Without considering that difficulty should stand in the way of accomplishing a desirable object which is possible and worth the expense, I would submit to those interested that it is practicable to manage an organ constructed on the principles I have proposed, and that it would give general satisfaction to the lovers of music—nearly the whole civilized world—to listen to it. I consider that the only great difficulty is in getting the requisite money applied to its cost. Still it is not impossible that some one who believes, or *knows*, what the result will be, will some time be able to build a great organ worthy of its name. If it will help its success—in view of the reluctance of organists to learn a new key-board—it might have, in addition to the enharmonic key-board, the common one with selecting apparatus, like that of the organ of 1849, to be managed by the feet of the organist, or by the fingers of the director. One of these key-boards, with the draw-stops and all necessary might be in front of the organ, facing forward, and the organist by turning on his seat could play on either, or another player could play at the same time.

ORGAN WITH TWO KEY-BOARDS, ENHARMONIC AND COMMON.



34. I propose to add to my organ—which now has the common key-board and transposition pedals—the enharmonic key-board; which will then be as represented here. But I think the new key-board alone sufficient.

35. In the theory I have advocated, the major keys are based on the first series of sounds (§ 12), and the minor keys on the sixths of the major keys, or on the series II. That there must be such a relation and order is inevitable. But respect for other authorities—among them Rev. Henry Liston, and especially Gen. T. Perronet Thompson—make it proper to mention that the major key of E may be taken on e, the third of the natural key; and that of the minor key on c, which I have assigned to the signature of three flats, may be taken on C, with the natural signature. Indeed, Mr. Liston in his organ of 1810, and Gen. Thompson in his of 1850, have this arrangement.* Musicians must decide upon the utility of taking the minor key of c upon the key-note of C major, or the scale of A♭ major with C of the

* The three key-boards of Gen. Thompson's organ give respectively the keys of C, e, and d: the scale of 4♯ being based on e, the third of the natural scale, and that of 2♯ on d, the sixth of 1♭, instead of on D, the second of the scale of C. The key-notes, D and A, their thirds, f♯ and c♯, and fifths, A and E, are given; but here this series of fifths ends. B and g♯ are not embraced in the forty-two notes of his octave, in which all are employed in thirds and fifths, and none for the perfect sevenths.

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natural scale as its third. If this is desirable, I have provided a finger-key at the back end of each black key, giving the minor third to the key-note, to which this black key gives the major third. For example, at the end of the key e, is E♭, minor third to C. This key is on a vertical wire with a circular head rising above the black key; and the whole key can be removed, if found to be in the way when not wanted. The sound, if introduced, will form a series VI (§ 12), and will require but eight extra organ pipes, whatever the number of signatures. The key-note of the ninth signature above, is but 0·09 of comma sharp for a minor third; but applying the correction (§ 30) needed for other notes, these minor thirds are made mathematically perfect. Thus the key-notes (see enharmonic table, p. 13,) C to D♯, become the series D♭♭ to E♭ (series VI, § 12), minor thirds respectively above the key-notes B♭♭ to C.

36. By transposing a scale by fifths, above or below, we first obtain a pitch widely different, and afterward approach that from which we started. For example, beginning with C we have G far removed, but in the next transposition comes D, only one diatonic interval—the tone—above C. Proceeding in the same direction, we shall ascend until at the seventh step we reach C♯, a large chromatic semitone above C. At twelve sharps B♯ is reached above C by what is called the comma of Pythagoras, or 1·09252 comma. This is the "*circle*" of the equal temperament, where the tuner divides this excess among the 12 fifths: making tolerable fifths, but intolerable substitutes for thirds. With twelve other notes for thirds, fair intervals could be had. At each successive twelve transpositions we rise by the same comma, until at fifty-three sharps the key-note is closer than ever to the starting pitch—only 0·16813 of comma sharp. If this small interval is divided among the 53 fifths, leaving each flat 0·00316 of comma, the circle will meet, and the octave will be divided into 53 equal intervals.* These are nearly exact for all the combinations of the triple diatonic scale, in these 53 keys. The fifths are as stated. The major thirds are 0·065 of comma sharp—near the limit where they draw into tune by "sympathy." In equal temperament they are sharp 0·63582.

37. The following table, page 21, serves to show: 1. this equal

* This is most readily done by its logarithm, viz., 0·00567,98112,88943,04142; which, added to itself 53 times, gives the log. of the octave, 2 : 1.

It is related that Mr. Briggs, in constructing his logarithms, in order to find the first small number, began with the number 10, and its logarithm 1, and extracted continually the root of the last number, and bisected its logarithm, till he arrived at the 53d and 54th roots and their annexed logarithms as here below: where he found that the decimals in the natural numbers are to each other in the ratio of the logarithms, or as 2 : 1.

	Numbers.	Logarithms.
53	1·00000,00000,00000,25563,82986,40064,70	0·00000,00000,00000,11102,23024,62515,65404
54	1·00000,00000,00000,12781,91493,20032,35	0·00000,00000,00000,05551,11512,31257,82702

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division into 53 notes, and how each division serves for six different notes in such close approximation that the eye would take them as one; 2. the perfectly tuned notes in their order as regards acuteness of pitch; as they result from successive transpositions by sharps and by flats to the 53d degree: and 3. any other adjustment in order to economize in the number of organ-pipes.

38. If the ear is content with the thirds 0·065 of comma sharp, we can have 53 signatures in sharps, and as many in flats—106 keys—complete in all except the perfect sevenths: these will all be supplied by 53 other pipes, making 106 pipes in the octave for what mathematically requires 640.

39. But there is an arrangement by which we can have perfect thirds and all other intervals. By flatting the fifths 0·0113 of comma, as described in § 30, and adding eight pipes, we have the triple diatonic scale perfect in 53 signatures, with 61 pipes. The perfect sevenths are supplied, and the double diatonic scales completed, by 53 additional pipes. For the minor mode we require 8 pipes each for the dominant thirds and sevenths; making a total of 130 to the octave for 53 keys absolutely perfect. They can be taken above or below the natural signature, as from 26 flats to 26 sharps: or in any other connected series of signatures. We should not have the circle joining exactly, § 36, but we should have perfect intervals within these wide limits. An enharmonic key-board for 53 signatures, on the scale I have drawn, would require about four feet of width, which could be divided into two or three boards.

40. Other adjustments can be made which are favored by the closeness of the intervals, and the large range within which the differences can be divided. In a temperament of 12 sounds, the grand difficulty is to dispose of a comma among 5 intervals, viz., 4 fifths and a major third—ignoring the chord of the seventh. The third of C, e, must serve for E. In any system the sum of the errors in these 5 intervals is always exactly a comma. The mean-tone temperament gives it all to the fifths, one-fourth of a comma each, and the equal temperament, dividing but one-twelfth to each fifth, leaves the third sharp by two-thirds of a comma. Here we have a difference of only one-eleventh of a comma, and have 8 fifths among which to divide it.

41. The following table gives the names of the key-notes of 106 regular transpositions by fifths, according to common musical rules, and the number of sharps or flats in the signature of each. It gives, besides, the thirds and dominant thirds of the minor mode which are closely approximate to the key-notes, together with the signature in which each note of the two latter series is found. A column of figures ascending from 1 to 54 indicates that there are so many notes arranged in the order of

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Division of the Octave into 53 intervals.

		Transposition by Sharps.						Transposition by Flats.					
		Key-notes.		Thirds.		Dom. 3ds. Rel. Minor.		Key-notes.		Thirds.		Dom. 3ds. Rel. Minor.	
		#s in Sig.	Letters. Times sharped.	#s in Sig.	Letters. Times sharped.	#s in Sig.	Letters. Times sharped.	bs in Sig.	Letters. Times flatted.	bs in Sig.	Letters. Times flatted.	bs in Sig.	Letters. Times flatted.
Octave, 2 : 1.	54	0	C 0 #	8	b 1 #	16	*a* 3 #	0	C 0 b	45	g 6 b	37	*f* 4 b
	53	41	F 6 "	49	e 7 "	4	*b* 1 "	12	D 2 "	4	c 0 "	49	*g* 6 "
	52	29	G 4 "	37	f 6 "	45	*e* 7 "	24	E 4 "	16	d 2 "	8	*c* 0 "
	51	17	A 2 "	25	g 4 "	33	*f* 6 "	36	F 5 "	28	e 4 "	20	*d* 2 "
	50	5	B 0 "	13	a 2 "	21	*g* 4 "	48	G 7 "	40	f 5 "	32	*e* 4 "
Si, Seventh, 15 : 8.	49	46	E 6 "	1	b 0 "	9	*a* 2 "	7	C 1 "	52	g 7 "	44	*f* 5 "
	48	34	F 5 "	42	e 6 "	50	*d* 8 "	19	D 3 "	11	c 1 "	3	*b* 0 "
	47	22	G 3 "	30	f 5 "	38	*e* 6 "	31	E 5 "	23	d 3 "	15	*c* 1 "
	46	10	A 1 "	18	g 3 "	26	*f* 5 "	43	F 6 "	35	e 5 "	27	*d* 3 "
	45	51	D 7 "	6	a 1 "	14	*g* 3 "	2	B 1 "	47	f 6 "	39	*e* 5 "
43¾ Perfect Seventh.	44	39	E 5 "	47	d 7 "	2	*a* 1 "	14	C 2 "	6	b 1 "	51	*f* 6 "
	43	27	F 4 "	35	e 5 "	43	*d* 7 "	26	D 4 "	18	c 2 "	10	*b* 1 "
	42	15	G 2 "	23	f 4 "	31	*e* 5 "	38	E 6 "	30	d 4 "	22	*c* 2 "
	41	3	A 0 "	11	g 2 "	19	*f* 4 "	50	F 7 "	42	e 6 "	34	*d* 4 "
La, Sixth, 5 : 3.	40	44	D 6 "	52	c 8 "	7	*g* 2 "	9	B 2 "	1	a 0 "	46	*e* 6 "
	39	32	E 4 "	40	d 6 "	48	*c* 8 "	21	C 3 "	13	b 2 "	5	*a* 0 "
	38	20	F 3 "	28	e 4 "	36	*d* 6 "	33	D 5 "	25	c 3 "	17	*b* 2 "
	37	8	G 1 "	16	f 3 "	24	*e* 4 "	45	E 7 "	37	d 5 "	29	*c* 3 "
	36	49	C 7 "	4	g 1 "	12	*f* 3 "	4	A 1 "	49	e 7 "	41	*d* 5 b
Dom. 3d, Minor.	35	37	D 5 "	45	c 7 "	0	*g* 1 "	16	B 3 "	8	a 1 "	0	*g* #
	34	25	E 3 "	33	d 5 "	41	*c* 7 "	28	C 4 "	20	b 3 "	12	*a* 1 b
	33	13	F 2 "	21	e 3 "	29	*d* 5 "	40	D 6 "	32	c 4 "	24	*b* 3 "
Sol, Fifth, 3 : 2.	32	1	G 0 "	9	f 2 "	17	*e* 3 "	52	B 8 "	14	d 6 "	36	*c* 4 "
	31	42	C 6 "	50	b 7 "	5	*f* 2 "	11	A 2 "	3	g 0 "	48	*d* 6 "
	30	30	D 4 "	38	c 6 "	46	*b* 7 "	23	B 4 "	15	a 2 "	7	*g* 0 "
	29	18	E 2 "	26	d 4 "	34	*c* 6 "	35	C 5 "	27	b 4 "	19	*a* 2 "
	28	6	F 1 "	14	e 2 "	22	*d* 4 "	47	D 7 "	39	c 5 "	31	*b* 4 "
	27	47	B 6 "	2	f 1 "	10	*e* 2 "	6	G 1 "	51	d 7 "	43	*c* 5 b
	26	35	C 5 "	43	b 6 "	51	*a* 8 "	18	A 3 "	10	g 1 "	2	*f* #
	25	23	D 3 "	31	c 5 "	39	*b* 6 "	30	B 5 "	22	a 3 "	14	*g* 1 b
	24	11	E 1 "	19	d 3 "	27	*c* 5 "	42	C 6 "	34	b 5 "	26	*a* 3 "
Fa, Fourth, 4 : 3.	23	52	A 7 "	7	e 1 "	15	*d* 3 "	1	F 0 "	46	c 6 "	38	*b* 5 "
	22	40	B 5 "	48	a 7 "	3	*e* 1 "	13	G 2 "	5	f 0 "	50	*c* 6 "
	21	28	C 4 "	36	b 5 "	44	*a* 7 "	25	A 4 "	17	g 2 "	9	*f* 0 "
	20	16	D 2 "	24	c 4 "	32	*b* 5 "	37	B 6 "	29	a 4 "	21	*g* 2 "
	19	4	E 0 "	12	d 2 "	20	*c* 4 "	49	C 7 "	41	b 6 "	33	*a* 4 "
Mi, Third, 5 : 4.	18	45	A 6 "	0	e 0 "	8	*d* 2 "	8	F 1 "	0	e 0 "	45	*b* 6 "
	17	33	B 4 "	41	a 6 "	49	*g* 8 "	20	G 3 "	12	f 1 "	4	*e* 0 "
	16	21	C 3 "	29	b 4 "	37	*a* 6 "	32	A 5 "	24	g 3 "	16	*f* 1 "
	15	9	D 1 "	17	c 3 "	25	*b* 4 "	44	B 7 "	36	a 5 "	28	*g* 3 "
	14	50	G 7 "	5	d 1 "	13	*c* 3 "	3	E 1 "	48	b 7 "	40	*a* 5 "
	13	38	A 5 "	46	g 7 "	1	*d* 1 "	15	F 2 "	7	e 1 "	52	*b* 7 "
	12	26	B 3 "	34	a 5 "	42	*g* 7 "	27	G 4 "	19	f 2 "	11	*e* 1 "
	11	14	C 2 "	22	b 3 "	30	*a* 5 "	39	A 6 "	31	g 4 "	23	*f* 2 "
Re, Second, 9 : 8.	10	2	D 0 "	10	c 2 "	18	*b* 3 "	51	B 8 "	43	a 6 "	35	*g* 4 "
	9	43	G 6 "	51	f 8 "	6	*c* 2 "	10	E 2 "	2	d 0 "	47	*a* 6 "
7¾ Dom. 7th, minor.	8	31	A 4 "	39	g 6 "	47	*f* 8 "	22	F 3 "	14	e 2 "	6	*d* 0 "
	7	19	B 2 "	27	a 4 "	35	*g* 6 "	34	G 5 "	26	f 3 "	18	*e* 2 "
	6	7	C 1 "	15	b 2 "	23	*a* 4 "	46	A 7 "	38	g 5 "	30	*f* 3 "
	5	48	F 7 "	3	e 1 "	11	*b* 2 "	5	D 1 "	50	a 7 "	42	*g* 5 b
	4	36	G 5 "	44	f 7 "	52	*e* 8 "	17	E 3 "	9	d 1 "	1	*c* #
	3	24	A 3 "	32	g 5 "	40	*f* 7 "	29	F 4 "	21	e 3 "	13	*d* 1 b
	2	12	B 1 "	20	a 3 "	28	*g* 5 "	41	G 6 "	33	f 4 "	25	*e* 3 "
Do, Key-note.	1	0	C 0 #	8	b 1 #	16	*a* 3 #	0	C 0 b	45	g 6 b	37	*f* 4 b

their acuteness or increasing rapidity of vibration. The first half of the table assigned to "transposition by sharps" is divided into three double columns, of each of which the first column gives the number of sharps in the signature where the note at its right is found in the relation of key-note, third, etc., as indicated at the head of the column. The keys in flats have three double columns arranged in like manner. In each double column the figure following the letter shows how many times this letter is sharped or flatted. We read |14|C 2♯| "signature 14 sharps, key-note C×" (C twice sharped or double sharp). |30|D 4♯| is "signature 30 sharps, key-note D× ×" (quadruple sharp).

42. Each of the 53 notes is approximate to the six which appear in the same horizontal line, and these are the sounds which are made identical by the small correction mentioned. For example, if we divide the octave into 53 equal intervals, § 36, the first note of the table—which see—will serve as (1) C, key-note of the natural signature; (2) b♯, third in 8 sharps; (3) $a^{\times}$♯ (triple sharp), dominant third to the minor key in 16 sharps; (4) C, as before; (5) g^{bbbbbb} (sextuple flat), the third of 45 flats; (6) f^{bbbb}, dominant third in the minor of 37 flats.* And in like manner, the six notes of each line will have the same pitch.

43. Interesting relations are found in this table. Every signature has 12 sharps or flats more or less than that which precedes. And by the division into groups of 5 intervals, curious coincidences appear. At the bottom of the first column of key-notes is C: each five intervals advance the signature seven degrees, and at the notes 6, 11, 16, etc., we have C with 1, 2, 3 sharps regularly to 36, where C sextuple sharp is key-note of 49 sharps; and C has maintained its place in eight successive groups.† There are many mathematical harmonies which point to the conclusion that music should be given in its purity, and in accordance with the laws of numbers, on which all the pleasure derived from listening to it depends.

ADDITION TO § 30.—The perfect sevenths of the major key, $A^{bb'}$ to F', answer for those of the minor key, g' to $e^{\sharp'}$; and the total of pipes in the octave will be 67.

* Notes several times sharped or flatted always bear to each other the same relation as respects these signs. The thirds of C, F, and G have the same chromatic signs as their roots. Thus the third of C is e; of C♯, e♯; of C××, e××. But the thirds of D, E, A, and B have *one sharp more:* the third of D is f♯; of D××, f××♯. When these letters are flatted, the rule holds good, by changing "*one sharp more*" to "one flat less." The letters whose thirds take one sharp more—or one flat less—are B E A D (see p. 13, note). Those which do not are G C F.

† In examining the relative vibrations of the notes in a series of fifths descending in the octave below, taking C as 1, the following notes are represented by these decimals, all of which are recurring or perpetually repeated. F, $0\overline{666}$; Bb, $0\overline{666}$; Eb, $0.\overline{666}$; Ab, $0\overline{790123456}$; Db, $0\overline{526748971,193415637,860082904}$. The ratio of the comma below, or c, is $0\overline{987654320,987654320}$.

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ART. II.—*A Sketch of the Geology of Southwestern Iowa;* by C. A. WHITE, M.D.

[In advance of his final report on the Geology of Iowa.]

WHATEVER may be the theories concerning the natural processes by which magnesian limestone has been formed, present indications strongly favor the opinion that with the close of the Subcarboniferous period its formation ceased among the rocks of Iowa. Very little limestone has been found among those rocks herein designated as the Lower Coal-measures, and the only analyses yet made of them are two, reported by Prof. Whitney, which yielded him less than one and a half per cent of the carbonate; but a considerable number of specimens of those here referred to the Upper Coal-measures have been examined by Prof. Hinrichs, the Chemist of the Survey, and in no case have they been found to contain so much as one per cent of magnesia —usually, only a trace.* A portion of these are perhaps stratigraphically equivalent with those in Missouri, which yielded Dr. Litton in one instance upward of twenty-six per cent of the carbonate.†

The dolomitization of the Devonian and Subcarboniferous rocks of Iowa is generally more complete in their northern extension, than farther to the southward. In the northern part of the state the Devonian rocks approach a true dolomite, but in the vicinities of Iowa City and Davenport, although still magnesian in part, some of the beds are tolerably pure limestone.

Parts of all the members of the Subcarboniferous series are more or less magnesian; the St. Louis limestone which forms the upper member of the series in this state, possessing that character in a marked degree in some of its beds, both in the northern and southern portions. The older rocks are so generally magnesian that no true limestone has been recognized in Iowa among those which occur between that of the lower Trenton period and the Devonian, along their outcrop; and the boring of the artesian well at Mt. Pleasant in Henry county (1125 feet deep) found the Niagara limestone and the so-called Hudson River shale possessing about the same characters as they do in the vicinity of Dubuque, two hundred miles to the northward.

* Dr. Geinitz states upon the authority of Prof. Marcou that certain of the rocks exposed at Nebraska City are dolomitic limestone, but no analyses are referred to. (See Geinitz on the "Carbonformation und Dyas in Nebraska," Dresden, 1866.) Analyses of specimens *from the same beds* on the Iowa side of the Missouri river, only twelve miles distant, show only a faint trace of magnesia.

† In the Geological reports of Missouri, Dr. Litton gives the results of fourteen analyses of Coal-measure rock, without stating whether they are from the upper, middle or lower series. Four of the analyses show no magnesia; one, a trace; one 8·90, one 8·94, and one 26·53. The average of all, excluding the last, is about two and a half per cent of the carbonate.

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These facts are mentioned in this connection, for the purpose of showing more clearly the lithological contrast between the Coal-measure rocks and those beneath them, in addition to the well known facts of their unconformability, and their natural paleontological differences.

Circumstances other than those suggested by geological features to be examined, rendered it desirable that the resumption of the state geological work should commence in the southwestern part, so that no opportunity has yet presented itself to make a complete examination of the full series of Lower Coal-measure strata, since this series does not appear at all in that part of the State, because the streams there have not eroded their valleys down to it through the upper series. This remark holds true of all that region composed of the counties of Decatur, Ringgold, Taylor, Page, Fremont, Mills, Pottawatamie, Montgomery, Cass, Adams, Adair, Union and Clarke. The greater part of last season's labors were expended in these, and other counties nearer the DesMoines river, and it is to this region almost exclusively that the following remarks upon the Upper Coal-measures are intended to apply. The Upper Coal-measure rocks are also known to be largely developed in the counties of Appanoose, Warren and Madison, and in these counties, along the Chariton, South, Middle and North rivers they are seen to rest on those of the lower series, the trend of the eastern border of the upper series passing through the last named and intervening counties, in a direction coinciding very nearly with the general course of the DesMoines river.

Although the Lower Coal-measures of Iowa have not been fully examined, yet a number of interesting facts have been collected concerning them by numerous visits to different localities. It has been satisfactorily ascertained that the lower series alone exists to the northward and eastward of the DesMoines river, the upper series lying to the southward and westward of it, but not extending so far as to its immediate vicinity. No definite knowledge of the entire thickness of the lower series has yet been obtained, but from data thus far collected it is not thought to average more than one hundred and fifty feet, but in some localities it is known to be much more, probably from local thickening of the strata.

Thus in Hardin county a section has been measured which reaches two hundred feet in thickness, and the presumption is strong that this does not represent the full series. The upper half of this section is a coarse ferruginous sandstone resting upon a four-foot bed of coal, all of which, with a part of the underlying fire-clay is seen exposed upon the bank of the Iowa river. The lower half is taken from a boring at the same locality which, according to the statement of the manager and the appearance

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of the material brought up, consists principally of bluish clayey shale. This boring was undertaken with the hope of finding a lower bed of coal, but was abandoned upon reaching the limestone. A remarkable fact in relation to this section, is the existence of the well defined border of the coal-field within two miles to the northeastward, where the Subcarboniferous limestone is seen well exposed. No satisfactory evidence of a disturbance of the strata could be discovered in the vicinity, and the bed of the Iowa river is the deepest point to which recent erosion has reached.

From these, and other similar facts collected along the border of the coal-field, it seems evident that the commencement of the Coal-measure epoch in Iowa found the then existing surface, whether of Subcarboniferous or Devonian rocks, very generally uneven by erosion; and not in consequence of any disturbance of the strata except the comparatively slight subsidence which caused the general unconformability before referred to. Instances of local accumulation of sandstone strata similar to that in Hardin county are not uncommon in the lower Coal-measures: those seen at Red Rock in Marion county, and below Ottumwa in Wapello county being of the same general character, and probably cotemporaneous deposits. These, and other irregular stratigraphical features in the series, will render its full elucidation a matter of some difficulty compared with similar labor in the upper series, which is composed to a large extent of limestones, and its horizons consequently more definite and extended. The lower series also, consisting as it does principally of friable sandstones and shales, presents comparatively few natural exposures of its strata, even where the drift material is not deep, and thus renders the topography of the region which it occupies readily distinguishable by the eye from that occupied by the upper series. It sems to be a well settled fact that nearly all the coal beds of the state belong to the lower series, the best beds being found in the lower part; and that this series alone can be properly designated as the productive Coal-measures of Iowa, since the upper series is now understood to contain but one bed of coal, the maximum thickness of which is only twenty inches.

Thus much by way of presenting the lithological contrast between the upper and lower Coal-measures as herein designated.

The most complete section found in all that region comprising the fifteen or sixteen counties before named, and perhaps the most complete one of the rocks of that age to be found in that state, was measured on the left valley-slope of Middle river, in the vicinity of Winterset, the county seat of Madison county. The strata of this section which are referred to the upper series, reach a thickness of one hundred and eighty feet, and are seen

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resting upon a bed of bluish, shaly, impure limestone which is referred to the lower series.

Twelve miles to the northward, the last named bed is recognized upon a branch of North river, with other beds below it, which are added to the former, and the whole designated as the Madison county section. It is numbered from the top downward.

Madison County Section.

	UPPER COAL-MEASURES.		
No. 1.	Thin bedded yellowish limestone,	1	ft.
No. 2.	Light bluish marlite,	4	"
No. 3.	Gray, massive limestone with dull fracture,	6	"
No. 4.	Gray, regularly bedded limestone with conchoidal fracture,	12	"
No. 5.	Black, laminated, carbonaceous shale,	2	"
No. 6.	Gray limestone with marly partings like No. 4,	34	"
No. 7.	Black shale like No. 5,	2½	"
No. 8.	Regularly bedded gray limestone with many cherty layers,	15	"
No. 9.	Compact limestone with concretionary structure,	2	"
No. 10.	Limestone of varying quality—in some parts siliceous and some of the interstitial material micaceous and finely arenaceous,	16½	"
No. 11.	Impure coal,	½	"
No. 12.	Light blue marlite,	2	"
No. 13.	Bluish, concretionary limestone, breaking readily into small fragments,	5	"
No. 14.	Bluish and reddish clays,	6	"
No. 15.	Sandy, micaceous shale, with fine grained micaceous sandstone in thin layers of bluish and greenish colors,	71	"
	LOWER COAL-MEASURES.		
No. 16.	Bluish, shaly, impure limestone,	2	"
No. 17.	Bluish clayey shale,	13	"
No. 18.	Coal,	2½	"
	Total,	197	ft.

It is considered probable that the members of the above section from No. 13 to No. 18 inclusive are equivalent to portions of the "Middle Coal-measures" of Prof. Swallow in Missouri, where the rocks of the whole epoch are more largely developed than in Iowa; but so far as these rocks of our own state have been investigated, they do not seem to warrant any other subdivisions than those here designated as the upper and lower series. The considerations, however, which have led to this subdivision are based principally upon lithological grounds, the result of observation in Iowa alone, and should future paleontological investigations suggest a change in this respect it will of course be made.

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No fossils were found in Nos. 14 and 15, yet they are known to have a wide geographical range. No. 13 seems to be somewhat local in its extent, not having been recognized outside the limits of Madison county. It contains numerous fossils, all of which seem to be somewhat dwarfed in size, two or three of the species not having been found in any other bed. No lamellibranchiates were found in it, nor in any of the beds beneath it, yet it is not improbable that they exist in both. Its fossils seem to be confined principally to gasteropods and to the spiriferoid and terebratuloid brachiopods. In the extreme southwestern corner of the county several feet of sandstone were found resting upon this bed, which is not seen at all where the section was measured. Thus it seems that both this sandstone, and No. 13 thin out in certain directions, but no indications of a true unconformability have been observed. No. 11 is a carbonaceous band, also of limited extent, not having been recognized outside the limits of the county.

The beds occurring between No. 7 and No. 11, as well as their equivalents elsewhere, are much more fossiliferous than other portions of the section. A widely extended carbo-argillaceous horizon is comprised within the vertical limits of these few beds, embracing the only bed of coal of the upper series, and also a number of associated strata which have resulted from the deposition of material that once formed a congenial habitat for lamellibranchiates and gasteropods in addition to the prevailing species of brachiopods. The two former classes of mollusks are much less numerous in all the other strata, and in the more clearly calcareous beds wherever found, the lamellibranchiates are comparatively rare and appear to be confined to the Anatinidæ. The six or seven upper members, except the carbonaceous beds, are principally calcareous, and contain few other than the more common upper Coal-measure species, being largely confined to the brachiopods.

The county of Madison contains extensive and very fine exposures of the rocks of the preceding section, but so rapidly do the six or seven upper members disappear in all directions from its center that they have not been recognized outside of its limits, except perhaps to the southeastward a short distance. Therefore these beds may be regarded as the most recent of the paleozoic rocks now known in the state. The only probable exceptions to this, are the gypsum beds of Fort Dodge, the age of which is not yet known; and a coarse-grained, friable, ferruginous sandstone, to which I have given the provisional name of Nishnabotany sandstone. The latter is found at numerous points in the region of the East Nishnabotany river, sometimes reaching a thickness of more than thirty feet, and extends down to within thirty miles of the Missouri state line. It has not been

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fully investigated, but is known to lie unconformably upon the upper Coal-measure rocks of that region, and is suspected to be a part of the Dakota group of Cretaceous rocks, and therefore of Mesozoic age.

The disappearance of the upper members of the Madison county section is of course most rapid to the eastward and northward, because the drainage, as well as the borders of the formation are in those directions. They are all found exposed on Clanton's fork of Middle river, as far southward as the village of Peru, but the next exposure of rocks to the southward is on the Missouri river water-shed, and belongs to the carbo-argillaceous horizon before referred to; but its bed of coal does not appear so far eastward. This is the most northerly exposure of rocks on Grand river, and is ten miles from the one last mentioned, and five miles eastward from Afton, the county seat of Union county. Fossils are numerous here in the thin calcareous bands between the layers of carbonaceous and argillaceous shales; lamellibranchiates and gasteropods predominating. Although a hundred miles eastward from Nebraska City, it is unmistakably of the same horizon as division "C" of Prof. Marcou's section there (loc. cit.), as shown by the identity and association of fossils at both localities, as well as by their stratigraphical relations.* Following down Grand river the stream is found to have a fall amounting to a little more than the general dip of the strata, and consequently makes its exit from the state with its bed in the representative of No. 15 of the Madison county section. Immediately westward from Winterset the upper beds also disappear, but somewhat less rapidly. The first good exposure in that direction, after leaving Middle river at the west line of Madison county, is on the East Nishnabotany river, some forty miles distant; yet so simple is the geology of this region that no hesitation is felt in referring the strata there to about the horizon of Nos. 8, 9 and 10 of the preceding section, particularly since that view is corroborated by observations on intervening ground to the southward. The next important

* Of the sixty-three species described and identified from division "C" of Prof. Marcou's section at Nebraska City by Dr. Geinitz, twenty-six are lamellibranchiates, and thirteen are gasteropods, which two classes of Mollusks contain the types which are principally relied upon by those gentlemen to prove the Permian age of the rocks at Nebraska City. I regret that I cannot fully agree with Dr. Geinitz in his identification of genera and species, yet I have been able to distinguish of those described and identified by him from that division, twenty species of those lamellibranchiates, and nearly half of those gasteropods, in the above named beds on Grand river; which beds are certainly not above the middle of the upper Coal-measure series as developed near the middle of the state. I moreover find that those lamellibranchiates and gasteropods with other species, characterize the horizon before referred to; the import of which is conceived to be that when they lived, they found there a congenial habitat, and not that the Permian period then and there commenced.

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exposure in that direction is near Crescent City, a few miles above Council Bluffs, and is referred to about the horizon of No. 16 of the same section. Thus it will be seen that the line of strike is practically east and west between Madison county and the Missouri river.

It was remarked that the fall of Grand river is a little greater than the southerly dip of the strata over which it passes, so that one finds lower beds exposed as he goes down the stream. This would be expected from the fact that the stream bears a little to the eastward, obliquely across a slight westerly as well as southerly dip; but the fall of all those streams between that, and the Nishnabotany river, is almost exactly coincident with the dip of the strata, wherever they have cut their valleys through the heavy drift deposit. This is clearly seen along the Nodaway river, where the bed of coal of the horizon before referred to, reaches its greatest development, and is found a little above the water at intervals, from the northern part of Adams county, to a point a few miles within the state of Missouri. The impure limestones associated with the coal bed, along the course of this river and its branches contain, both above and below the coal, but more especially below it, very many species of fossils identical with those at the locality on Grand river just referred to, and also with those at Nebraska City, which Dr. Geinitz and Prof. Marcou refer to the Permian period. (loc. cit.)

No other rocks except those of this horizon appear along the Nodaway, but the Tarkeo has bared the equivalent of No. 15 of the previous section, in the northern part of Page county, as has also the East Nishnabotany, in Montgomery county. The lower part of the carbo-argillaceous horizon is occasionally seen in the valley slopes of those two streams, but its bed of coal is not seen west of the Nodaway, until the bluffs of the Missouri river are reached in the northwestern part of Fremont county, at the locality before mentioned, where the coal has diminished in thickness to six inches. The same bed of coal also diminishes in thickness as one goes down the Nodaway, being found only ten inches thick just within the state of Missouri; and to the eastward it thins out entirely before reaching Grand, or Middle river.

The following section was measured in Fremont county at the base of the bluffs, twelve miles northeastward from Nebraska City. It is numbered from the top downward and designated as the

Fremont County Section.

No. 1.	Thin bedded yellowish limestone, - - -	4½ ft.
No. 2.	Marly and carbonaceous shales, - - -	7 "
No. 3.	Impure coal, - - - - - - - -	½ "
No. 4.	Light bluish fire clay with fossil grasses? - -	2 "

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No. 5.	Compact bluish limestone with shaly partings, -	4	ft.
No. 6.	Yellowish and bluish marlites, - - - -	6	"
No. 7.	Gray limestone with small concretions, - -	4	"
No. 8.	Unexposed, - - - - - - - -	6	"
No. 9.	Compact gray limestone, - - - - - -	1½	"
No. 10.	Light yellow indurated marl, - - - - -	4	"
No. 11.	Yellowish siliceous limestone with flinty masses, -	2½	"
No. 12.	Yellowish earthy shale with concretionary layers of limestone, - - - - - - - - -	3	"
No. 13.	Compact, gray limestone, - - - - -	1	"
No. 14.	Yellowish earthy shale, - - - - - -	2	"
No. 15.	Heavy bedded limestone, with dull fracture, * -	3	"
No. 16.	Bluish shale, - - - - - - - - -	½	"
No. 17.	Soft, yellowish siliceous stone, crowded with Fusulina,	1½	"
No. 18.	Massive, light gray limestone with dull fracture,	16	"
No. 19.	Bluish marlite with 9 inch band of limestone, -	4½	"
No. 20.	Compact bluish limestone with small concretions,	2	"
No. 21.	Bluish marlite, - - - - - - -	4	"
No. 22.	Bluish, thin-bedded, fine-grained, micaceous sandstone,	1½	"
	Total,	81	"

The localities of the two sections here given are nearly one hundred miles apart, yet their equivalencies are very satisfactorily determined. No. 22 of the Fremont county section is regarded as equivalent with No. 15 of the preceding one; and the remainder of the Fremont county section, as equivalent with that portion of the preceding one between the lower portion of No. 6, and the top of No. 15. No. 7 of the Madison county section is regarded as equivalent with Nos. 2 and 3 of that of Fremont county, both belonging to the carbo-argillaceous horizon before described. Beneath this horizon, and more or less associated with it, there is quite a definite Fusulina horizon, which forms a conspicuous stratigraphical feature in the southwestern counties, but since these fossils range through the entire upper series they cannot always be relied upon for stratigraphical determinations. It is quite otherwise, however, with the horizon first named, for we are able to recognize this, with more or less certainty all over the region in question, both by its bed of coal, or carbonaceous character where that does not exist, and also by its peculiar paleontological features.

The subject may be briefly summed up thus:

1. Besides the usual paleontological and lithological differences between the Coal-measure rocks and those beneath them, there seems to be in Iowa almost an entire absence of magnesia in the former rocks, while it prevails so largely in those of older date.

2. The lower Coal-measures contain nearly all the coal of the state, and are composed principally of sandstones and shales.

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3. The lower Coal-measures alone are found along the Des-Moines river, and to the northward and eastward of it.

4. The upper Coal-measures lie wholly to the southward and westward of that river, the receding borders of that formation resting conformably upon the lower series. Consequently the rocks of the upper series do not reach the border of the Coal-field, nor do they ever lap upon the rocks of older date than the lower Coal-measures, as they are supposed to do in Illinois.

5. The region more particularly described in this article is comprised within that portion of the three southern tiers of counties lying between the Missouri river, and a line running southward from the city of DesMoines.

6. The rocks of this region belong principally to the upper Coal-measures, which are seen resting upon the lower Coal-measures at the eastern border.

7. A few beds of the upper series thin out, but no true unconformability is recognized.

8. The upper series is believed to contain but one bed of coal, properly speaking, the maximum thickness of which is twenty inches, and its greatest development along the Nodaway river.

9. The stratigraphy of the whole region is very simple, the line of strike being practically east and west, and the dip, to the southward nearly coincident with the fall of the streams.

10. The highest Paleozoic beds are to be found in Madison county and belong to the upper Coal-measures.

11. The lowest beds exposed along the Missouri river, or upon its water-shed within the region herein described, belong also to the upper Coal-measures as designated on the previous pages.

12. No Subcarboniferous rocks are found westward from the immediate vicinity of the DesMoines river.

13. There is a definite carbo-argillaceous horizon recognized over the greater part of this region which is characterized by the bed of coal before referred to, and in the strata of which lamellibranchiates and gasteropods prevail, and sometimes predominate.

14. Above this horizon as well as below it, characteristic upper Coal-measure brachiopods, and other fossils prevail.

15. Below this horizon the rocks increase in thickness and calcareous character from east to west, and probably also to the southward.

16. Nishnabotany sandstone occurs in the counties of Mills, Montgomery, Cass and Pottowatamie. It lies unconformably upon the upper Coal-measure rocks, and is supposed to be of Cretaceous age.

Iowa City, Iowa, March 27th, 1867.

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ART. III.—*Notes on the Geology of Kansas;** by F. V. HAYDEN.

PERHAPS few portions of the globe of the same size have furnished more facts and collections of interest to scientific men, both in Geology and Paleontology, than those drained by the Missouri river and its tributaries. Since 1853 the greater part of my time has been devoted to the development of the geology and natural history of this great region. During that period I have personally examined the greater part of the territories of Kansas, of Nebraska, Dakota, Montana, Idaho and Colorado, and it is but natural that I should read with great care and interest a publication on the geology of any portion of that country emanating from any other source. It was on this account that an official report on the Geology of Kansas by Prof. Swallow was hailed with pleasure. In the summer of 1858 Mr. Meek and the writer made a careful examination of a large portion of Kansas from Leavenworth City westward to Smoky Hill, and the results of that exploration were published in the Proceedings of the Academy of Natural Sciences at Philadelphia, Jan. 1859. In that paper opinions were advanced in regard to the relations of the Permian to the Carboniferous rocks which were accepted by most of the geologists in this country and in Europe. In the report of Prof. Swallow, however, opinions have been expressed on some points opposite to those in the paper above referred to, and it is the object of this article to pass these opinions under review. Mr. Meek has furnished some carefully prepared notes which form the substance of this article.

Although Prof. Swallow acknowledges (p. 43) that these Permian strata (his Lower Permian) graduate into, and are so nearly conformable to, the Coal-measures below, that "no want of conformability can be detected by examining any one locality, though the line of junction be traced a long distance;" "Yet," he continues, "when sections are made across the line of junction at distant points, it becomes evident that there is a striking non-conformability. When the sections made across this line on the Kansas, at Manhattan and above, are compared with those on the Blue, though separated by several miles, there is no difficulty in identifying all the important strata in one with those of the others; and when these sections are compared with those at Mill Creek, some 25 miles east, and with those on the Cottonwood, 60 miles south from Manhattan, the prominent beds are easily identified down to the lowest of the Permian, No. 84 of the above section; but Nos. 85–95 from the section near Manhattan are not found, when No. 84 rests directly down

* Preliminary Report of the Geological Survey of Kansas. By G. C. SWALLOW, State Geologist. Printed at Lawrence, Kansas, 1866.

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upon the *Fusulina* shales." Now the facts here mentioned, even if we admit that the very same beds have not been mistaken for others, or the contrary, from a change in their lithological characters at different localities, do not establish non-conformability as that term is used by geologists. As properly used in geology, the word unconformable is applied to two or more beds or sets of strata, resting one upon another, and dipping at different angles or in different directions in consequence of the older beds being tilted from their horizontal condition previously to the deposition of the later ones. Such disturbances or want of conformity in the planes of strata, are usually accompanied by differences in the groups of fossils above and below the line of non-conformity, and thus indicate a considerable change of physical conditions, as well as the lapses of long periods of time, between the deposition of the discordant strata; and hence are usually admitted as marking the close of one period and the introduction of another. The mere thinning out in some given direction of particular beds and thickening of others, however, may occur in any part of the same formation without indicating any such disturbances, lapse of time, or changes of physical conditions between the deposition of the beds above and below the horizon of the locally absent strata. Every one who has studied our western Coal-measures attentively, must be aware that nothing is more common than the thinning out of particular beds of considerable thickness, sometimes even between no very distantly separated localities. Lesquereux has shown this to be the case at various horizons in the Coal-measures of Kentucky, Illinois and other western States, as well as Pennsylvania. For instance, in speaking of Coals No. 1B, and 1C (Ill. Report, i, p. 216), he says they are usually separated by 55 feet of strata, but "from the absence of the strata separating these beds of coal, they sometimes come in contact, forming a single bank." Again, on page 218 of the same report in speaking of the divisions of bed B often found separated by a thin parting of clay, he mentions an instance of this parting, which is sometimes entirely wanting, swelling out from a mere seam so as to form a bed of shale 10 feet in thickness, in a distance of only 300 yards. Again (ib., p. 228), in speaking of the Colchester bed (Coal No. 3) generally separated from the conglomerate, or mill-stone grit, by from 170 to 200 feet of strata, including coals, 1B, 1C and 2, he says that, "by an apparently abnormal deposition of the Coal-measures, which I have tried to explain elsewhere, the Colchester coal almost immediately overlies the conglomerate formation," thus showing from 170 to 200 feet of intervening strata to be wanting here.

In the same Report, he has shown, that in tracing the Coal-measures a little west of north from southeastern Illinois where

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this whole series is well developed, and has been clearly identified by him from its fossil plants with the Coal-measures of Europe as well as with the various members of the same formation in Indiana, Kentucky, Ohio and Pennsylvania, it is found that almost the whole of the series below the horizon of the "Anvil rock" six or seven hundred feet in thickness of the Kentucky section, has thinned out and disappeared at the northern margin of the Illinois Coal-field, so as to leave the Upper Coal-measures, and some portions of the Lower resting directly down upon Silurian rocks. Facts like the latter are evidently to be accounted for, either by supposing the northern part of the state to have been more elevated than the southern at the commencement of the coal epoch, and that as the whole area became gradually more and more depressed, the marshes, or whatever conditions gave origin to the coal, extended farther and farther northward with the formation of each successive bed; or that the southern districts sank more rapidly than the northern, and consequently received several successive beds that did not extend far northward in consequence of the greater elevation of that region at this period of their deposition. More local instances, however, like those mentioned by Prof. Swallow, of the thinning out of particular beds are evidently to be accounted for by the erosion of one or several beds in places, before the deposition of others upon them. Prof. Lesley mentions an instance of this kind in the Lower Coal-measures of Cannelton, Ia. (see Owen's Indiana Report, p. 345), where a bed of shale 46 feet in thickness thins out and entirely disappears in a distance of two miles, so as to bring directly down, upon a bed of coal, a stratum of sandstone, separated from it at another locality so near by the whole thickness of shale just mentioned. These local erosions of one or more beds previous to the deposition of others have occurred in various formations, but more particularly in the Coal-measures. On this subject Lesquereux says (note, p. 211, Ill. Report, i), "local erosions at any part of the thickness of the Coal-measures are of frequent occurrence." When we consider the conditions under which the Coal-measures were probably formed, the wonder is that such facts are not more common than the contrary. Hence we should be very cautious in viewing them as evidences of a break in the series, such as marks the close of one condition of things, and the introduction of a new epoch.

But we will now turn to the groups of fossils found in these so-called Lower Permian rocks, and see how far they sustain the opinion that there was a physical break of the importance claimed, separating them from the Upper Coal-measures. As Prof. Swallow, with few exceptions, mentions in the Report under review only by their generic or class names the fossils found in the rocks under consideration, we have to refer to his papers pub-

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lished in the Transactions of the St. Louis Academy of Sciences in 1858, and in the Am. Jour. Sci., vol. xxvi, p. 182, of the same year, for his views in regard to their specific relations. In these papers he shows by a tabular arrangement the range in the various rocks of each species mentioned, as he understood them. In these lists he enumerates about 70 species of Upper Coal-measure and Permian fossils, 16 of which he shows to be common to the Upper Coal-measures and his Lower Permian, and two to the latter and the Upper Permian.

The following well known, and, with one or two exceptions, widely distributed species of our western Coal-measures, are those given by him as common to the Lower Permian and Upper Coal-measures, viz: *Productus semireticulatus*, *P. Rogersi*, *P. aequicostatus*, *Spirifer cameratus*, *S. planoconvexus*, *S. pectinifera? Chonetes Flemingii*, *Orthisina umbraculum*,* *O. Missouriensis*, *Rhynchonella Osagensis*, *Terebratula? subtilita*, *Myalina recta*, *M. subquadrata*, *M. Kansasensis*, *Allorisma Minnehaha*, and *Natica Pricei;* he also identifies with this *Macrocheilus spiratus* McCoy, a Subcarboniferous species. With the exception of *Spirifer pectinifera* Sowerby, with which we are not acquainted, and *Macrocheilus spiratus*, we know all of these common Coal-measure species occur abundantly in the so-called Lower Permian of Kansas; also the following other Coal-measure species, viz., *Aviculo-pecten occidentalis* (*Pecten Cleavlandicus* of Prof. Swallow's list), *Nautilus occidentalis* Swallow (afterward described from the Coal-measures of Illinois by McChesney under another name), *Fusulina cylindrica* in great numbers (or the Coal-measure forms generally referred to that species in the west), *Chonetes mucronata*, *Productus Calhounianus*, *Euomphalus rugosus* Hall (not Sowerby), a small *Spirifer* often referred to *S. lineatus*, *Phillipsia Cliftonensis* Shumard, and others. From the same so-called Lower Permian Prof. Swallow also positively identifies 10 European Permian species, and some 5 or 6 others with doubt; also with doubt, 1 Subcarboniferous species, 3 Triassic, and 1 Liassic European forms.

We may, however, well question the accuracy of these determinations, by which Carboniferous, Permian, Triassic and Liassic species are made to occur together in the same beds, especially in beds known to contain so many of our commonest Coal-measure species, and four genera, i. e., *Petalodus*, *Phillipsia*, *Bellerophon* and *Fusulina* not known in the Permian of Europe. Prof. Swallow says in regard to this so-called lower Permian, that the appearance at this point of numerous new fossils, many of which are well known Permian types, of the genera *Monotis*, *Bakevellia*, *Schizodus*, *Pleurophorus*, *Synocladia* and *Tham-*

* We use the names as given in the list. *Orthisina* as now restricted is a Silurian genus, and the *Natica* is a *Naticopsis*.

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niscus, clearly indicates the introduction of the Permian age. The genus *Monotis*, however (as the name is here applied), also occurs far below the horizon where he would make the line of separation,—hundreds of feet, indeed down in what he includes in the Coal-measures, even near the level of the Missouri at Leavenworth, Kansas; it is also now known to occur in Illinois at a point near the horizon of the eleventh Coal-bed, above which the Coal-measures are well marked. All the other genera mentioned, and most of the very same species likewise occur in the admitted Upper Coal-measures of Kansas and the adjoining states, while *Pleurophorus* and *Schizodus* occur in the Subcarboniferous rocks of Illinois. Indeed there is now known a species of *Pleurophorus* from the Keokuk Limestone, of the Mountain Limestone series, at Warsaw, Illinois, as nearly like the European Permian, *P. costatus*, as any known form in Kansas rocks.

From all these facts, we think the evidence, both paleontological and stratigraphical, bears directly against the idea of there being a proper break in the series at the horizon mentioned by Prof. Swallow, much less "a striking non-conformity." The very fact that the missing strata, the absence of which on Mill creek is regarded as proving a break, do occur in their proper place on Kansas and Blue rivers, only 25 miles distant, shows clearly that this is one of those cases of the erosion of particular beds at certain localities, previous to the deposition of others, so common in the Coal-measures, and not one of the great general disturbances of the order of things, such as produced non-conformity of the beds, and usually accompanied the introduction of a new fauna. Nor should any great weight be given to the general lighter color of the beds above the supposed break; for every one knows how little reliance can be placed on mere color and other lithological characters in distinguishing formations.* In addition to this, the change of color is not abrupt, while lighter and darker beds continue to alternate above the supposed break, and to a less extent below it.

All the evidence sustains the opinion expressed by Meek and Hayden in 1859 (Proc. Acad. Nat. Sci., Jan. 1859), that there is in Kansas an unbroken series from the Coal-measures to the top of the Permian of this region; and that no one studying these rocks and their fossils, without any previous knowledge of the classifi-

* It may be of some interest to state here, that the matrix containing some fossils recently sent to the Smithsonian Institution by Mr. E. G. Squier, from an island in Lake Titicaca, South America, 14,500 feet above the sea, and now being studied by Mr. Meek, could not be distinguished, lithologically, from some of the Permian strata of Kansas, and the Black Hills in Nebraska. And yet these rocks in the high Andes have been referred by D'Orbigny and other eminent European authorities to the Mountain limestone. The fossils, however, from Lake Titicaca, agree in several instances with those of our western Coal-measures.

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cations adopted in the old world, would have separated the Permian at all from the Coal-measures, as distinct groups. Starting far down in the Coal-measures below the supposed line of separation, we have, along with great numbers of all our common Coal-measure forms, an occasional *Monotis* (so-called), *Bakevellia*, *Pleurophorus*, *Myalina*, &c., that might apparently, in some instances, be even identified specifically with European Permian species. As we ascend in the series, we find that, after going some distance above the supposed line of demarkation, the Carboniferous species gradually begin to disappear, and the Permian types become rather more common, in particular beds, until we have ascended to a point near the horizon Prof. Swallow makes the line between the Upper and Lower Permian, when we find we have almost completely lost sight of the familiar Carboniferous species, a few of which had continued on up to near this point, and see scarcely any but forms such as in Europe would be regarded as Permian types. There is no physical break here, however, nor *abrupt* change of fossils. Hence Meek and Hayden regarded the beds below the horizon down so far as to include most, if not nearly all, of Prof. Swallow's Lower Permian, as an intermediate connecting series between the Permian and Coal-measures which, if worthy of a distinct name at all from the latter, should be called Permo-carboniferous, while the beds above, they regarded alone as properly the equivalent of the true Permian of Europe.

The occurrence of a few types that would generally be regarded as Permian, along with numerous well-known Coal-measure species, far below the true Permian, only accords with facts observed in other formations in this country, where certain types evidently made their appearance here long before they are known to have appeared in Europe. In this connection we need but refer to the Cretaceous plants of Nebraska, most of which belong to genera, and some of them to species, scarcely distinguishable from forms known in Europe in rocks not older than the later Tertiary. Even one of the best botanical paleontologists of Europe thought some of them probably identical with Miocene species, and yet they hold a position near 800 feet below beds containing numerous species of *Ammonites*, *Baculites*, *Scaphites*, *Inoceramus*, and various other unquestionably Cretaceous types. Similar facts have also been brought out by the California Survey. It is also worthy of note that in several cases these few Permian types occurring far down in the Coal-measures in Kansas appear in particular layers, similar to the Permian rocks in composition, and alternating with other beds containing only Carboniferous fossils, much like Barrande's "Colonies" in the Silurian rocks of Bohemia.

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In regard to the Permian discovery in Kansas, we regret to see that Prof. Swallow (doubtless inadvertently) here in an official report, uses language, which when taken in connection with the fact that he nowhere alludes to the labors of others in that region would lead some to think he had intentionally ignored the agency of any other parties in that discovery and was claiming it as wholly his own. Thus in a note at the bottom of page 42, after speaking of the discovery of Permian rocks in Kansas, he says "this discovery was first announced by myself Feb. 22, 1858. See Trans. Acad. Sci. St. Louis, vol. i."

We had supposed the dispute in regard to this discovery was long since amicably settled, when Prof. Swallow published in this Journal, [2], vol. xxvi, page 188, in a paper on the Kansas Permian, the statement that "it is but just to state in this connection, that, so far as I know, Mr. Meek first discovered the Permian character of the Kansas fossils, and communicated to Maj. Hawn his impression on this subject on the 3d of Sept., 1857. He also mentioned his discovery, as I am informed, to some friends at the Smithsonian Institution on the 17th of January, 1858, and communicated the same to Prof. Leidy, on the 16th of March.* Maj. Hawn frankly declares that his first impressions that the rocks in question might be Permian are due to Mr. Meek." We may be mistaken; but the literal wording of Prof. Swallow's note quoted above, in connection with his silence in regard to the agency of others in this discovery, might be understood, without some explanation, as indicating an intention to claim it on the strength of the fact that his announcement, communicating the discovery to a regularly established scientific institution at an earlier date than the reading of Meek and Hayden's paper before the Albany Institute, gave him a right to claim it as entirely his own. On this ground, however, Meek and Hayden would still be in advance, for they had not only made it known verbally to friends in Washington, about the 17th of Jan., 1858, but actually had a record made of it at the Smithsonian Institution, (as all know, established for the increase and diffusion of knowledge) on the 19th of Jan., 1858. This record or memorandum, which we are permitted to give here, was written by Prof. Baird and reads as follows:—

"1858, Jan. 19th, Mr. Meek and Dr. Hayden showed me a series of fossils arranged on the table of room 110, from Dr. Hayden's collections under Lieut. Warren in 1857, which they stated

* This latter date is doubtless a misprint for 16th of Jan., for the discovery was actually published on the 4th of March, 1858, by Meek and Hayden in a paper read before the Albany Institute on the 2d of March, 1858, extras of which were distributed by them two days after, and before the issue of Prof. Swallow's paper alluded to above: though Prof. Swallow had a short time previously published a note on the subject in a St. Louis newspaper. He also published another notice in this Journal, issued, if we mistake not, between 4th and 10th of March, 1858.

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to represent in succession, first, Potsdam Sandstone from the Black Hills; 2d, forms indicating Permian both in Kansas and the region of the Black Hills; 3d, fossils of the Jurassic type from the region of the Black Hills; 4th, Carboniferous from the Black Hills. (Signed) S. F. BAIRD."

This memorandum is not noted in the order the fossils were arranged; the clause in regard to the Carboniferous was accidentally omitted between the Potsdam Sandstone and the Permian, and then added at the end after the Jurassic. Nor is any mention made of the fossils sent from Kansas to Mr. Meek by Mr. Hawn, nor of a small collection from the same region communicated by Dr. Cooper which were at the same time lying on the table; though both of these gentlemen received full credit for collecting and sending these fossils, in the paper published by Meek and Hayden.

It is with considerable reluctance that this subject, which we had thought entirely settled, has been touched upon here; but the facts already mentioned seemed to demand such a statement. At the same time that Meek and Hayden manifest no desire to ignore the connection of Mr. Hawn and Prof. Swallow with the Permian discovery, they have the right to expect their own agency in the matter to be acknowledged, especially in an official report on the geology of that region, treating upon this formation and speaking of the labors of others in that connection.*

In Prof. Swallow's former papers, he gives the total thickness of the Upper and Lower Permian as he understands them, at 820 feet, and in the report under review the thickness of the same beds is given as 704 feet 1 inch. This is quite as near an

* We have made some remarks in regard to the Permian discovery in this article, not with the idea of convincing any one at all familiar with the facts of the case, for several of the ablest geologists of the present time have indicated directly or indirectly their opinion on this matter, but because our silence might be taken as entire submission to the apparent disposition on the part of some geologists to ignore our agency in the development of the geology of the West. No true-minded geologist in reading Prof. Swallow's statements under his own signature as given in this article and the note by Mr. Meek appended to a paper published in the Trans. Albany Institute, March 2d, 1858, can possibly err in regard to the *real* discoverer of the Permian in Kansas. During the year 1857, I had the good fortune to be connected as geologist, with a U. S. exploring expedition to the Black Hills under the command of Gen. G. K. Warren, U. S. A. Among some fossils I had collected at various points in the Black Hills and along the Missouri river, were forms much like those of the Permian of Europe. Maj. Hawn and Dr. Cooper had also sent to Mr. Meek collections from Kansas. In numerous letters from Mr. Meek while I was in the West he continually impressed upon me the importance of looking out for Permian fossils. In a letter dated Oct. 20th, 1857, he said he had received "some fossils sent on by Maj. Hawn evidently either Upper Coal-measure forms or *Permian*, I would not be astonished if they should prove to be the latter." Again, Nov. 10th, 1857, speaking of some fossils I had sent him from near Nebraska City, "among them I think I recognized a *Monotis* [*Pseudomonotis*], a genus not known in the old world in older rocks than the *Permian*." F. V. H.

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agreement as could be expected in the measurement of such variable strata at different localities; yet when there is a difference of 116 feet, and the numerous subordinate beds composing the whole are stated as varying in thickness at different places from 1 to 15 feet, 4 to 12 feet, 10 to 25 feet, and so on, one would naturally suppose that the odd inch might have been dispensed with in summing up the whole, as it gives the appearance of minute exactness, manifestly unattainable in the measurement of such strata.

In regard to the beds referred with a ? by Prof. Swallow and Mr. Hawn to the Trias in Kansas, we can only say that they may be Trias, Permian or even Jurassic, so far as any evidence yet obtained goes. With those gentlemen we are much inclined to believe they will be found to belong to the Trias. They are known to hold a position immediately above Permian beds and beneath the Cretaceous, while they are very similar to portions of the Trias of Europe in their lithological characters. At the same time, it is by no means demonstrated that they may not prove to belong to the Permian. Prof. Swallow, at first, referred to this horizon a trilobate exogenous leaf, a small bivalve he thought doubtfully identical with *Nucula speciosa* Münster, from the Muschelkalk (not a true *Nucula* by the way), and another shell he thought identical with *Myophoria orbicularis* Goldf. (sp.) As Prof. Swallow now only alludes to the supposed *Nucula*, and makes no mention of the *Myophoria* in his report, in speaking of this rock, it is probable he has found the latter to be a *Schizodus* or some other type from the Permian; and as the trilobate leaf is now known to be from the Cretaceous, as shown by Meek and Hayden, the paleontological evidence yet obtained of the Triassic age of these beds seems to be narrowing down to a single little bivalve, of doubtful genus. It is true Prof. Mudge thinks he has found bird tracks in a sandstone of this horizon, but as he also speaks of finding exogenous leaves in the same position, it seems probable that the tracks mentioned by him are from the sandstone belonging to the Cretaceous, in which so many leaves have been found in that region. We must therefore await further evidence before we can regard the existence of the Trias in eastern Kansas as demonstrated.

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ART. IV.—*On the systematic value of Rhynchophorous Coleoptera:* —an Abstract of a Memoir read before the National Academy of Sciences, at Washington, Jan. 24th, 1867; by JOHN L. LECONTE, M.D.

IN the empirical arrangement of the families of Coleoptera, which has resulted from the adoption of the tarsal system of division, the families contained in the great natural group of Heteromera are followed by the Curculionidæ and Scolytidæ, which, more or less subdivided into smaller families, have been supposed to establish a linear relation between the rostrated Heteromera (Salpingus, Rhinosimus, &c.) to the Cerambycidæ and Chrysomelidæ, the great types of the Pseudotetramera, or Subpentamera, of various authors.

It is the object of the present investigation to determine the limits, and the relations of the first mentioned of these types, the Rhynchophora.

The inferiority of this type is manifested, not only in the larval condition by the limited number or absence of visual lenses, the want of locomotive appendages, the feeble development or entire want of antennæ, and the unchitinized epidermis; but also by the combination in the imago of characters belonging to a perfectly developed organism with others pertaining to an inferior grade in the scale of Coleoptera.

Thus, for instance, while we perceive in the other series of beetles, that the lower forms retain certain larval characters, as evidenced by the extension of the coxæ, the imperfection of the anterior coxal cavities, the softness of the integuments, and the want of centralization in the abdomen, all such degradational characters are absent in the Rhynchophora.

Other characters representing low grades in their respective series do not appear in the Rhynchophora, such as vegetative growth of the organs of sense, indicated by pectinate or flabellate antennæ, or excessive length of palpi.

On the contrary, we find in the Rhynchophora, that the integuments are perfectly chitinized: the elytra never abbreviated or wanting; the anterior coxæ are always completely enclosed; the ventral segments, usually five, never exceed six in number.

The plan of degradation, in passing from the higher to the lower forms, is by the extension of the longitudinal axis of the body, in its anterior half; this is usually most strongly manifested in the head, and exhibited not only by the length of the beak, but by the conformation of the lower floor of the mouth.

Commencing with those Curculionidæ (Adelognathi *Lacordaire*,) in which the mentum fills the gular emargination, as in the

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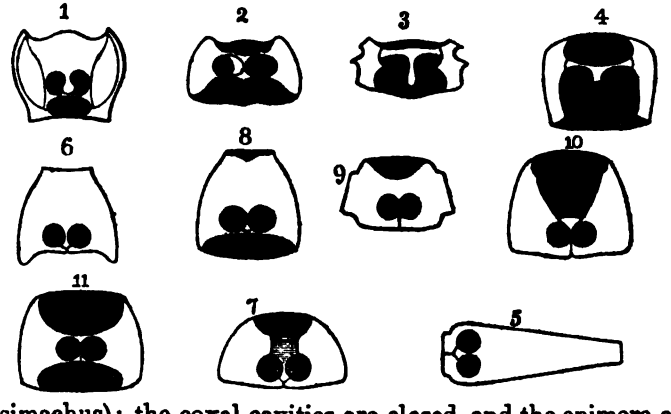
higher Tenebrionidæ, we find a gradual lessening in size of the mentum, itself becoming supported upon a broad, short, gular peduncle, permitting the maxillæ to become visible, (Phanerognathi, Cohort 1, *Lacordaire*): next the gular peduncle becomes elongated, and bilobed, receiving the mentum, now reduced to very small size, between its lobes (Phanerognathi, Cohort 11, and also Brenthidæ, and Anthribidæ).

Having in the continuance of my work on the Classification of Coleoptera of North America, recently commenced a critical study of our Rhynchophora, I became aware of the impossibility of intercalating them between the Heteromera and Subpentamera, and am now convinced that they represent a special type, which must be isolated from all other types of Coleoptera, possessing a systematic value equal to all the others combined.

In seeking for the characters which should define this type, I observed a remarkable difference in the arrangement of the pieces of the under surface of the prothorax, heretofore overlooked, and so far as I know, confined to this particular type.

In other Coleoptera, the prosternum is either extended behind the anterior coxæ, so as to form part of the hind margin of the segment, thus coming in contact with the mesosternum, or it is cut off between the coxæ, and in this case (as in many others) the coxal cavities are open behind: in the few exceptions (Derodontus, Dacoderus) in which the coxæ are contiguous and the cavities closed behind, the prosternum still extends behind the coxæ, to the hind margin of the segment, as is shown by the short sutures separating the epimera from the medial piece of the prosternum.

I have represented these modifications of form in the adjoining wood-cuts. Fig. 1, under surface of prothorax of a Carabide



(Pasimachus); the coxal cavities are closed, and the epimera and episterna well defined. Fig. 2, do. of a Scarabæide (Lachnoster-

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na): the coxæ are transverse, the cavities closed, the side pieces not distinct. Fig. 3, do. of Cucujus; coxal cavities open behind, side pieces not distinct. Fig. 4, do. of Telephorus: coxal cavities confluent and open behind.

In Rhynchophora the prothoracic sutures are obliterated, there is no separation between the prosternum and episterna, and very rarely between the latter and the pronotum: the coxal cavities, frequently confluent, are always closed behind, *by the epimera*, which become connate on the median line, enclosing the hind part of the prosternum, thus cutting it off completely from the mesothoracic segment.

Fig. 5 represents this arrangement of parts in a Brenthide, in which family the extreme limit of degradation by linear extension is reached. Fig. 6, under surface of prothorax of a Calandride (Rhynchophorus). Fig. 7, do. of Cryptorhynchus. Fig. 8, do. of Balaninus. Fig. 9, do. Ophryastes. Fig. 10, do. Thecesternus. Fig. 11, do. Dendroctonus.

When the coxæ are contiguous, the point of the prosternum is visible behind them, but is none the less perfectly enclosed by the growth of the side pieces to the median line.

Another evidence of the inferiority of type of the Rhynchophora, which has not been mentioned, is seen in the functions performed by the beak, which in the lower groups, especially in the female, becomes greatly elongated. The occurrence of corneous exserted ovipositors in other orders of insects is not rare: a few species of Coleoptera (certain Valgus, for example) have the last abdominal segment prolonged, simulating such an organ. But it was reserved for the Rhynchophora to exhibit a degradation of type, by which a function, peculiarly appropriate to the posterior extremity of the body, is performed by the head: the elongated beak becoming in fact the ovipositor.

Thus the inferiority of grade, evidenced in other series of Coleoptera by the softness of the integuments, or by the permanence of larval forms, chiefly in the abdomen and coxæ, is in the Rhynchophora manifested by the transfer of a function from the posterior to the anterior part of the body, and the linear extension of the latter, in accordance with this 'change of base.'

The principles of classification of Rhynchophora, and their division into families will be discussed in a subsequent memoir. It is, however, proper to observe that the peculiar construction of prothorax above described as characteristic of the Rhynchophora, is not exhibited in the Bruchidæ, which family, as observed by Lacordaire (Gen. Col. vii, 600), should be viewed as closely related to, if not actually a portion of, the great family Chrysomelidæ.

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ART. V.—*On the Morphological value and relations of the Human Hand;* by BURT G. WILDER, S.B., M.D.

[Abstract of a paper read before the National Academy of Sciences, Aug. 8, 1866.]

THE morphological relations of the human hand are of three kinds.

1st, Its *special homology* with the terminal segment of the anterior extremity in other vertebrates.

2d, Its *general homology* as a part of the skeleton; which can be fully enunciated only after a decision as to the morphological relations of the scapular arch of which it is an appendage.

3d, Its *polar homologies* with the corresponding parts on the *opposite side* and at the *opposite end* of the body. That with the other hand is universally regarded as one of *symmetry* or *antagonism;* that with the foot is generally called its *serial* homology, and the point under consideration is whether this is merely a serial relation and not rather one of antagonism, so as to constitute a second kind of polar homology.

The course of the argument is indicated by the following propositions.

1. The extreme diversity and confliction of opinion* as to the morphological *relations* of the human hand are chiefly due to an over-estimate of its morphological *value.*

2. This misappreciation of the morphological value of the hand is due to a non-recognition of the distinctions between the two principles, morphology and teleology.

3. Morphology is the law of internal form, of plan, of essential structure. Teleology is the law of special function which determines size, shape and general appearance.

4. Homology is morphological identity; analogy is teleological resemblance; and neither relation necessarily implies the other.

5. Morphology treats of unity of type; teleology treats of adaptation to ends.

6. Morphology alone would be law without liberty, which is despotism; teleology alone would be liberty without law, which is anarchy.

7. Morphology is conservative and tends toward centralization; teleology is radical and tends toward diffusion.

8. The two principles may be traced in all structures, but the one is often more prominent than the other.

9. With certain important qualifications it may be said that the clearest manifestations of morphology are to be observed in

* Some idea of this diversity of opinion may be gained by reference to Dr. Cleland's brief statement of the views of various authors in the 7th edition of Quain's Anatomy, pp. 115–117, 1866, and to the remarks of Mivart, Linnæan Transactions, vol. XXV, p. 400.

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organs which are *central* or *proximal*, *simple*, *rudimentary*, and *constant;* while teleology displays itself in organs which are *peripheral* or *distal*, *complicated* and *subject to variation.*

10. Man is the most perfect animal in a functional point of view, and the hand is *peripheral in its position*, *complicated in function* and *subject to variation* both in the zoological series and by arrest or excess of development: and forasmuch as it has, during all ages and by all classes of minds, been regarded as a typical illustration of perfection of detail and harmonious arrangement of parts in strict conformity to the elevated offices which it performs, *therefore to the same extent must we disregard it in our endeavor to determine questions of morphology.*

11. Hands and feet, but especially the former, are as unsafe guides to the homology of the limbs, as the cranial and caudal regions would be to the characters of a typical vertebra.*

12. In discussing the relation between the fore and hind limbs, we must free our morphological comparison from all consideration of special function.

13. The fore and hind limbs are appendages of the anterior and posterior regions of the body; and whatever general laws are observed in the body, are, on *a priori* grounds, to be looked for in the limbs.

14. Polarity, or something analogous to the polar forces of physical science, is a primary law in the formation, the structure and the general functions of the vertebrate body;† for the existence of this, evidence is furnished by embryology, anatomy, physiology, and pathology.‡

15. The anterior and posterior regions of the body are, as it were, the two poles of a longitudinal axis, and their constituent parts are more or less completely homologous, repeating each other in opposite directions like the corresponding organs upon the right and left sides.

16. This polar or antagonistic relation of similar parts may easily be traced in the proximal segments of the limbs in many mammalia; the front of the thigh and the convexity of the knee are readily compared with the back of the upper arm and the convexity of the elbow.

17. Of the two pair of limbs, the anterior is the more subject to variation and is therefore less reliable for morphological purposes.

* On a cat with supernumerary digits; Proceedings Bost. Soc. of Nat. Hist., May 16, 1866.

† See the writings of Oken: also description of a double fœtus, by Prof. Jeffries Wyman, Bost. Med. and Surg. Journal, March 29, 1866; and classification of Herbivores, and Cephalization, by Prof. James D. Dana, this Journal, vol. xxxvii, p. 158, and vol. xli, p. 164.

‡ See paper by the writer on Pathological Polarity, Bost. Med. and Surg. Journal, April 5, 1866, and on Morphology and Teleology especially in the limbs of Mammalia, Memoirs Bost. Soc. Nat. Hist., vol. i, No. 1, 1865.

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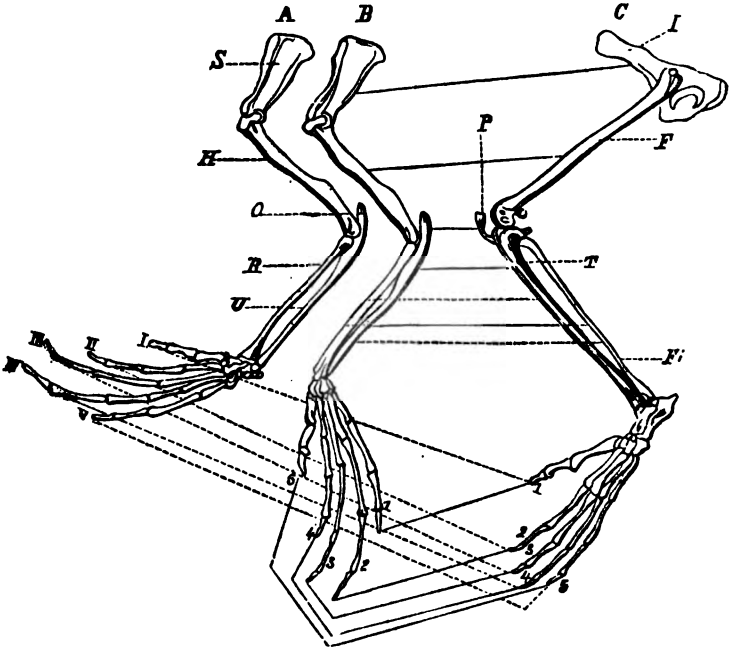
18. By reference to the less modified hinder limb we find that, as a rule, *two contiguous segments bend in opposite directions.*

19. By comparing the proximal segments of the hinder limb with those of the fore limb, we find that *two corresponding segments in the two limbs point and are flexed in opposite directions.*

20. Conformity with these two rules is all that would be necessary for maintaining the *balance* of a *geometrical figure* or a *stationary being;* but to enable an animal to *move*, the terminal segments of both limbs must face in the same direction; in the quadrupeds this is usually accomplished by a rotation of the radius upon the ulna so as to face the palm backward, or as in the Aye-aye *inward*, like the sole.

Limbs of left side of Aye-aye (*Cheiromys Madagascariensis* Cuv.), (altered from Owen.)*



A, Fore-leg in *natural attitude*, the hand being more or less *pronated.*

B, Fore-leg in *normal position*, the hand *supinated* so as to be symmetrical with the foot.

C, Hind-leg. S, Scapula; I, Ilium; H, Humerus; F, Femur; O, Olecranon; P, Patella; U, Ulna; T, Tibia; R, Radius; Fi, Fibula.

Homologous parts are joined by continuous lines. Analogous parts are joined by dotted lines. The homologous digits of B and C are numbered 1, 2, 3, 4, 5, starting from the so-called little finger and great toe. The Roman numerals attached to the digits of A indicate their analogies with those of C.

* Menegraph of the Aye-aye, plate vii: Comp. Anat. and Physiology of Vertebrates, vol. ii, fig. 343.

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21. This is the *natural attitude* of the terminal segments of the fore-limb, but that it is not a *normal position** in which they may be compared with their posterior representatives, is seen from their want of conformity to the principles manifested by the less modified hinder limb and by its own proximal segments (Propositions 18 and 19), and also from the more or less complete crossing of the two bones of the fore-arm, while those of the leg are parallel with each other.

22. These three discrepancies are wholly removed by *supinating the hand* and placing it, *palm downward with the fingers pointing backward* and the *wrist in front* just as the toes point forward and the heel is behind.

23. The *ulna* is now wholly upon the *inner* side of the fore-arm and corresponds to the *tibia* while the *radius* corresponds to the *fibula;* their variations as to size and shape and their being soldered together in many species are all teleological modifications and ought not to enter into the discussion of a morphological relation.

24. The *thumb* is thus left upon the outer side of the hand and corresponds by position with the *little toe*, while the *little finger* is upon the inner side and corresponds with the *great toe.*

25. These correspondences are, in my opinion, the true *homologies* while the relation between the ulna and fibula, the radius and tibia, the thumb and great toe are merely *analogies* and dependent upon teleological modifications.

The paper contained a more extended discussion of some points and a review of the later European memoirs upon the subject; but in the hope that we may shortly be favored with the views of Prof. Jeffries Wyman upon the important questions involved, the writer confines himself for the present to the foregoing abstract with the following additions as the result of subsequent investigations.

A. The conclusion reached as to the normal position and homology of the thumb, though contrary to the common opinion, is confirmed by all purely morphological considerations.

B. The lack of exact correspondence between the carpal and tarsal bones in most mammalia and between the nerves and the arteries in the human hand and foot where alone they have been compared, is due to teleological modifications, the necessity for which is yet to be explained.

C. The difference in the number of phalanges, which has always been looked upon as a very essential distinction between the thumb and great toe and the other digits, is really, like the

* For a forcible statement of the necessity for distinguishing between the natural attitude and the normal position of animals, see Agassiz's contributions to the Nat. Hist. of U. S., vol. iii, part 1, p. 76; it throws a great light upon this relation of the limbs.

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generic variations as to the number of the digits themselves, a difference of *quantity* and therefore teleological in its character.

D. Finally, even if there were not many vertebrates in which this difference does not exist, and if there were not on record several cases of human thumbs having three phalanges, yet, unless we are prepared to sacrifice position to quantity, we have no more reason for denying the homology of the thumb and great toe with the little toe and little finger respectively than we have for denying a homology between the third finger of man and that of a whale because the former has some additional phalanges, or between the foot of man and that of a dog because the former is composed of five digits while the latter has but four.

ART. VI.—*On the Classification of the subdivisions of McCoy's Genus Athyris, as determined by the laws of Zoological Nomenclature;* by E. BILLINGS, Paleontologist of the Geological Survey of Canada.

[Read before the Nat. Hist. Soc., Montreal, March 25, 1867.]*

EVERY naturalist who has studied the paleozoic brachiopoda is aware that there exists a very great diversity of opinion with regard to the classification of the several sections into which the old genus *Athyris* has been divided. The arrangement which I and some others have adopted is, in substance, the same as that proposed by Mr. Davidson in the first edition of his "General Introduction," published in 1853.† Although this has been ob-

* After the reading of this paper the subject was discussed by some of the members of the Society. The following is from a short report published in the newspapers at Montreal: "After the paper was read, Dr. P. P. Carpenter said that he thought that Mr. Billings had clearly established his point, and gave an account of the history of a committee appointed by the British Association to make laws to regulate scientific nomenclature, of which committee he was a member. Mr. Whiteaves stated that he was satisfied with the correctness of the view Mr. Billings had taken, and made some remarks about scientific nomenclature, and upon some structural points in the shells of the genus in question. Principal Dawson deplored the confusion that has arisen through conflicting views on the question of nomenclature, and agreeing with Mr. Billings in the conclusion he had come to, said that this communication was valuable inasmuch as it cleared up a question that had hitherto been rendered obscure."

† Modified by separating *Merista* thus:

GENUS.	TYPE.
Athyris McCoy, 1844,	*A. tumida* Dalman.
Spirigera D'Orbigny, 1847,	*S. concentrica* von Buch.
Merista Suess, 1851,	*M. Herculea* Barrande.

The recent classification differs from the above as follows:

Meristella Hall, 1860,	*A. tumida.*
Athyris or *Spirigera*,	*S. concentrica.*
Merista,	*M. Herculea.*

According to this, either *Athyris* or *Spirigera* must be suppressed, in order to make room for *Meristella*. See this Jour., [2], xxxi, 292, xxxiii, xxxvi, ii.

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jected to by several distinguished paleontologists, and in consequence thereof, abandoned by its author, yet I believe that on a careful examination of all the circumstances, it will be found to be perfectly just toward the parties concerned, and in no respect inconsistent with the rules of zoological nomenclature. It was the first subdivision of the genus published, and should therefore take precedence over all others.

Previously to 1853, *Athyris* was only known as a single large genus of brachiopoda which included such forms as *Terebratula concentrica* von Buch, *T. tumida* Dalman, and *T. Herculea* Barrande. In that year Mr. Davidson divided it into two smaller genera, confining the name *Athyris* to that section for which it was most appropriate, with *tumida* or *Herculea* for the types; and adopting *Spirigera* D'Orbigny for the other type, *T. concentrica.* It was afterward found that *Athyris*, as then re-defined, included two genera, and in consequence it has been again divided by separating all those typified by *T. Herculea* under the name of *Merista*, a genus proposed, but not clearly characterized by Prof. Suess, in 1851. This is the classification which I believe to be the true one. While discussing it I shall, throughout this paper, when I may have occasion to refer to the species above-named, designate them, *Athyris tumida*, *Spirigera concentrica*, and *Merista Herculea.*

Those who are opposed to this arrangement contend, that as all the species which McCoy placed in the genus, at the time he first described it, belong to the group typified by *S. concentrica*, the name *Athyris* must be retained for that group, and cannot now be transferred to the other section of which *A. tumida* is the type. This reasoning, according to my views, can only hold good in case it be first proved that McCoy specially confined the genus to species having the generic characters of those in his original list, or pointed out one of them as the type, or drew up his diagnosis in such a manner as to exclude *A. tumida.* In this paper I shall endeavor to show:—

1. That McCoy did not limit his genus to the species first placed in it.

2. That on the contrary he and other naturalists understood it to include both *A. tumida* and *S. concentrica.*

3. That according to the laws of zoological nomenclature the subdivision made by Davidson in 1853 cannot be set aside.

4. That Davidson's classification has been adopted into several works, some of them of great influence and wide circulation.

In order to prove the above propositions, I shall give the more important facts of the history of the genus, with McCoy's original figure, and shall quote some of the laws above mentioned in full. Much of this, of course, belongs to the common stock of knowledge of all paleontologists conversant with the fossils of the older

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rocks, and might be thought superfluous. But the question is somewhat complicated and cannot well be decided, unless in view of all the circumstances. Besides this, it is one upon which any good naturalist is perfectly competent to give an opinion, although specially engaged in other departments. Few of these have access to works on paleozoic fossils, and therefore for the convenience of such as may feel inclined to investigate the subject, it is desirable to bring all the facts togather.

There is no dispute about the extent of the genera, and therefore, the details of the internal characters need not be given. It is purely a question of Natural-History Ethics, if I may be permitted to use such a term.

1. *History and extent of the original Genus.*—The original description was published in the "Synopsis of the Carboniferous Fossils of Ireland" in 1844. From this work I shall make some extracts, and shall introduce along with the original figure two others to further illustrate the subject.

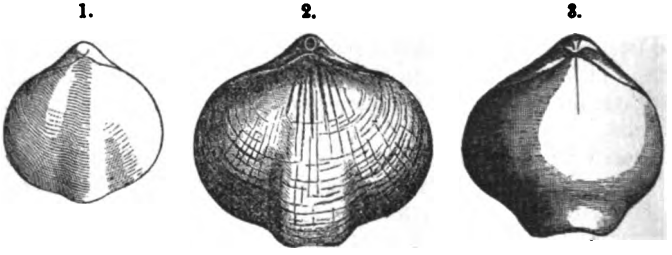

Fig. 1—Copy of the original figure given by McCoy (without a specific name) to illustrate his idea of the general form of an *Athyris*.

Fig. 2—*Spirigera concentrica* von Buch. The form is copied from Davidson's Monograph of the British Devonian Brachiopoda, pl. III, fig. 13, Pal. Soc. for 1862. The right-hand side is, in this copy, a little restored, and the aperture in the beak made larger than it is in the original figure.

Fig. 3—*Athyris tumida* Dalman. Copied from Davidson's "General Introduction," pl. VI, fig. 73.

The following extracts are from McCoy's work above referred to:—

"The family *Delthyridæ* appears to be divided into the five following genera: 1. *Spirifera* Sow., composed of those longitudinally-ribbed species, in which the hinge-line is equal to, or exceeds the width of the shell, the cardinal area with parallel sides, the cardinal teeth of the ventral valve (now called the dorsal valve) large, spirally rolled, and having a triangular foramen beneath the beak of the dorsal (ventral) valve. 2. *Martinia* McCoy, or the smooth Spirifers, in which the hinge-line is less than the width of the shell, and the cardinal area triangular. 3. *Athyris* McCoy, in which there is no vestige of either foramen, cardinal area, or hinge-line. This remarkable genus is frequently confounded with those shells usually named *Terebratula*, in the older rocks, but is distinguished by the large, spiral appendages, which are wanting in the

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other group. 4. *Brachythyris* McCoy, in which we find the longitudinally-ribbed surface of *Spirifera*, united with the short hinge-line of *Martinia*. 5. *Orthis* Dal., in which there are no spiral appendages, the hinge-line and striæ frequently spinose (as in *Leptæna*), and the cardinal area common to both valves, and its sides inclined toward each other at its angles; dorsal valve smallest."—*Op. cit.*, page 128.

On page 146 of the same work, he thus concisely describes the genus:—

"*Gen. Ch.*—Nearly orbicular, small; no cardinal area or hinge-line; spiral appendages very large, filling the greater part of the shell.

"This very interesting group possesses all the external characters of the *Terebratulidæ*, united to the internal structure of the Spirifers, to which latter family it truly belongs. Professor Phillips is the only author who has recognized the group: he forms of it his last division of the genus *Spirifera*, but gives no characters to distinguish it from *Terebratula*; the internal structure is, however, a sure guide."

The above is all that he wrote about the genus at that time; and it will be perceived, that he does not point out any particular species, as the type: and farther, that there is nothing in his remarks from which it can be inferred that he knew anything about the genera into which the group was afterwards subdivided. Consequently, it is impossible that he could have intended to confine the genus to any one of them; as is now affirmed by some of the naturalists who are opposed to the classification advocated in this paper. Instead of excluding species with an imperforate beak such as *A. tumida*, the etymology of the word *Athyris* (without a door or opening), the expression, "in which there is no vestige of either foramen, cardinal area or hinge-line," and, also, his typical figure all induce the belief that he had before him one or more forms with the beak entire. This is rendered certain by what he says on page 147. Speaking of what he calls *A. concentrica*, he says: "This species is not uncommon; it is figured in the Bull. de la Soc. Géol. de France, with a perforated beak as in *Terebratula*. I have, however, seen numerous specimens with the beak entire and imperforate, as in the other Paleozoic species." It is highly probable from all this that he had in view such Silurian forms as *A. tumida*. This latter species is so common that it is almost certain that such a collection, as he was then engaged upon, would contain one or more specimens.

If we take the paragraph (No. 3) as a part of the generic description, then *A. tumida* is included. If, on the other hand, we confine ourselves to the extract from p. 146, it is not excluded, as there is no reference made there to the structure of the beak. This latter diagnosis is sufficiently comprehensive and general in its terms to include *Athyris*, *Spirigera* and *Merista*. He did not place *A. tumida* in the genus, for the reason that his

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work was confined altogether to the Carboniferous fossils, among which it does not occur. But he did so afterward when he described Professor Sedgwick's Silurian fossils, as will be shown farther on. He was wrong in supposing that all the species were imperforate, a matter of little consequence, as it was simply an error of observation which does not vitiate. Had the genus turned out to be not capable of subdivision, all that could be done now with this error would be to strike it out. There was sufficient in his diagnosis to indicate what group of fossils was intended. He was also wrong in supposing *S. concentrica* to be a Carboniferous fossil: it is Devonian. It may be that he mistook some other species with an imperforate beak for that. It will be seen farther on that Prof. King made a similar mistake with respect to this very species, having taken *T. scalprum* Barrande, for it; an error which was detected by Mr. Davidson. Altogether, he referred eleven species to the genus, several of which have been shown to be synonyms.

In the same work he proposed another genus, *Actinoconchus*, but as it was founded on error, he afterward withdrew it, and added it to *Athyris*. (Brit. Pal. Foss., p. 436). All scientific works abound more or less with such misconceptions.

That the genus was understood by other naturalists to include *A. tumida* is proved by the following facts. It is well known that the genus *Spirigera* was proposed by D'Orbigny, in 1847, simply as a substitute for *Athyris*, on the ground that this latter name implies the absence of a foramen, and is, therefore, not appropriate for species with a perforated beak. It is quite clear that D'Orbigny considered his genus to be precisely the same in extent as *Athyris*. All the species, therefore, which he placed in *Spirigera* he regarded to be fairly within the group, and it is unquestionable that he would have referred them all to *Athyris* had not that name appeared to him objectionable. I have not seen his original description in the "Annales des Sciences Naturelles," referred to by Mr. Davidson, in the extract given below, but in the "Paléontologie Française," vol. iv, page 357, he says: "This division has already two generic names which we cannot preserve, because they are in complete contradiction with zoological characters." The two genera referred to were *Athyris* and *Actinoconchus*.

He specially selected *T. concentrica** for the type of his genus, and therefore if *Spirigera* be retained at all it must be for that section. He refers to his "Prodrome" for a list of the species, and we have thus only to examine this list in order to ascertain his idea of the extent of the genus. They are the following, taking them in the order in which they are published:

* "Le type est *T. concentrica* de Buch. Toutes les espèces avec leur synonymie se trouvent dans notre *Prodrome de paléontologie stratigraphique*."

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S. Ceres, vultur, Circe, passer, Herculea, harpya, Hecate, tumida, concentrica, Helmerseni, Puschana, decussata, plebeia, Ferronesensis, Ezquerra, Hispanica, Toreno, subconcentrica, Pelapayensis, Campomanensis, Mayendorfi, Roissyi, serpentina, lamellosa, ambigua, Blodena, planosulcata, expansa, pentaëdra, pectinifera, trigonella, quinquecostata, quadricostata, tricostata and *cristigalli.*

Several of the above species do not belong to the group. This list shows that D'Orbigny regarded the genus as including not only the types of *Athyris* and *Spirigera* but also that of the genus *Merista* (*M. Herculea*) which I shall notice farther on. I think it quite certain that had D'Orbigny been aware that the genus was capable of subdivision, he would have retained *Athyris* for one of the groups which have the beak imperforate. Indeed, according to the laws of nomenclature, he could not have done otherwise with any probability of producing a permanent classification.

In a valuable paper, read before the Geological Society of France, in May, 1848, on the Brachiopoda of the Upper Silurian rocks of England,* Mr. Davidson made the following observations on D'Orbigny's genus:

Vient ensuite le genre *Spirigera* que le même auteur établit pour les coquilles qui possédent des spires internes placés de la même manière que les *Spirifer*, mais qui ont des appendices et des détails d'organisation essentiellement différents. Ces espèces, parmi lesquelles nous trouvons les *Terebratula, tumida, Circe, concentrica, subconcentrica, Roissyi, pectinifera, ambigua, Helmerseni, Pelapayensis, Campomanensis, Ferronesensis, Ezquerra, Hispanica*, ont déjà été distinguées par M. de Verneuil comme devant former une section à part, qu'il a nommée la section des *Concentricæ.* Je suis de l'opinion de M. d'Orbigny qu'elles doivent constituer un genre. L'étude minutieuse que M. Bouchard a faite de la *Terebratula concentrica* ne m'en laisse aucun doute; mais ce genre n'ayant pas encore été convenablement caractérisé, je m'abstiendrai de l'adopter dans ce petit mémoire qui n'est pour ainsi dire qu'un résumé d'un plus grand travail que je publie en ce moment dans le *London Geological Journal.*

Upon the above I shall only remark that it is quite clear that Mr. Davidson then regarded *S. concentrica* and *A. tumida* as congeneric; and that whatever new genus might be established, it would include both species.

In 1852, McCoy, in the 2nd Fasciculus of the "British Paleozoic Fossils," page 196, re-defined *Athyris* as follows:—

"*Gen. Ch.*—Nearly orbicular or ovate, both valves convex; no cardinal area, foramen, or hinge-line: spiral appendages to beak of entering valve very large, nearly filling the shell; a strong mesial septum in the rostral part of entering valve; dental lamellæ moderate; tissue of shell apparently fibrous.

* *Mémoire sur les Brachiopodes du Système Silurien supérieur d'Angleterre*, par M. Th. Davidson, Bull. Geol. Soc. Fr., v, pp. 309, 314.

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"One specimen (of *A. tumida*) shows the pallial and ovarian impressions to be thick, numerous, and dichotomising frequently from beak to margin."

In the work cited and in the 3d Fasciculus, we find the following species:—*A. tumida*, & *concentrica*, *ambigua*, *De Roissyi*, *expansa*, *globistriata*, *globularis*, *gregaria*, *paradoxa*, *pectinifera*, and *squamigera*. This shows clearly enough his views of the extent of the genus, that is to say, that as it was then understood, it included both *A. tumida* and *A. concentrica*. In commenting on this, Prof. Hall says:—"The fact that McCoy cited this* as an Athyris, no more renders it an *Athyris* than it was made *Atrypa*, by being thus described by Dalman; and it was just as free for the foundation of a genus after the citation of McCoy as before." This is true enough, in part. It was free for the foundation of a genus until 1853, when Davidson used it for that purpose; but since 1853, it has never been free.

The above is quite sufficient to prove my first and second propositions.

I am not aware that any thing else of much importance, with the exception of what relates to *Merista*, having been published up to 1853, when Davidson's excellent work, the "Introduction to the Classification of the Brachiopoda," made its appearance, in which the genus was first subdivided. But, before entering upon this, I shall notice the remarks of Prof. Suess, on the genus *Merista*.

This genus was proposed by Prof. Suess, in 1851, but he did not then sufficiently characterize it. The following is all that I can find, relating to it, that was published previously to 1853.

"Mr. E. Suess communicated the results of the investigations on several Brachiopods, from the Bohemian transition rocks, which had been made by him and Mr. Custos Dormitzer, of Prague. He showed that some of the forms heretofore referred to *Terebratula* had no opening in the beak, for the passage of the muscle of adhesion; and, also, that the distribution of their inner organs points to an affinity with the non-attached genus Pentamerus. These inner organs are borne by six partitions in place of a single calcareous loop; the spiral arms are not unrollable.

"Through the separation of these forms (for which the name *Merista* is proposed) from the genus *Terebratula*, an apparent contradiction in the laws of paleontological distribution is solved, since these smooth forms will now be separated, which have heretofore offered an apparent contradiction to the present views of these laws."

Lest I should not have expressed his views rightly in this free translation, I give the original in the note below.†

* This Jour. II, xxxii, 181.

† "Herr Eduard Suess theilte die Erfolge der Untersuchung einiger Brachiopoden aus dem böhmischen Uebergangsgebirge mit, die er gemeinschaftlich mit Herrn Custos Dormitzer in Prag angestellt hatte. Er zeigte, dass mehrere bisher zu den

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On page 160 of the same work, there are some farther remarks on the classification of the brachiopoda, by Prof. Suess, in which he refers to the genus *Merista*. No generic description is, however, there given. It appears also that it was again noticed in "Leonhard's Neues Jahrbuch, p. 127, 1854." I have not, at present, access to that work, and do not know whether the genus is described there or not: at all events, at the time Mr. Davidson prepared the English edition of his "General Introduction," *Merista* was not understood.

Prof. King in his "Monograph of the Permian fossils of England" (1850) proposed to restore the genus *Cleiothyris* of Phillips, apparently making it partly equal to *Athyris* McCoy. But the specimen on which this arrangement was founded, was afterward shown to Mr. Davidson, and by him identified with *T. scalprum* Barrande (now *Merista* scalprum), while *Cleiothyris* was intended by its author as a substitute for *Atrypa*. (See Davidson's Introduction, p. 85.)

2. *Subdivision of the Genus by Mr. Davidson in* 1854.—From all the facts above given it may be gleaned that in 1853, when Mr. Davidson was engaged in the preparation of his General Introduction, this group of Brachiopoda was known as a single genus but with two generic names *Athyris* McCoy, 1844; *Spirigera* D'Orbigny, 1847. Each of these was intended by its author to include the whole group. McCoy was under the impression that all the species had the beak imperforate, while D'Orbigny maintained that they were all perforated. Both authors were partly wrong and partly right. The genus was capable of subdivision, but no one had as yet undertaken that task; unless indeed, the observations of Prof. King and Suess can be so construed. With regard to the latter, as the genus *Merista* is now well understood and is different from *Athyris*, it does not affect the question. *Cleiothyris* may be considered as obsolete.

Mr. Davidson in his "General Introduction" in endeavoring to reconcile the conflicting nomenclatures of D'Orbigny and McCoy divided the genus, retaining the name *Athyris* for "forms with an apparently imperforate beak or closed foramen, variously disposed septa and largely developed dental plates." He

Terebrateln gezählte Formen an ihrer Spitze keine Oeffnung für den Anheftungsmuskel besitzen, und dass auch die Vertheilung ihrer inneren Organe auf eine Verwandtschaft mit der ebenfalls nicht angehefteten Gattung Pentamerus hinweist. Diese inneren Organe werden von 6 Wänden, statt von einer einfachen Kalkschleife getragen; die Spiralarme selbst sind nicht aufrollbar."

"Durch das Lostrennen dieser Formen, für welche der Name *Merista* vorgeschlagen wird, von der Gattung, *Terebratula*, wird zugleich ein scheinbarer Widerspruch in den Gesetzen paläontologischer Verbreitung gehoben, da eben jene glatten Arten ausgeschieden werden, welche den bisherigen Ansichten über diese Gesetze am schroffsten entgegengestanden waren."—*Jahrbuch der k. k. geologischen Reichsanstalt, Vienna*, ii, pt. 4, pp. 150, 160. 1851.

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selected two species, "*A. tumida* Dal. or *Herculea* Barrande," and specially named them as the types.

He retained *Spirigera* for the group of which *S. concentrica* is the type. As to this latter group, by whatever name it may be hereafter known, its extent will most probably always be that assigned to it in the work in question.

The genus *Athyris*, however, as there defined, included *Merista*, a circumstance which, however, as I shall presently show, in no way vitiates the arrangement. In a note, he states,—"before coming to the above conclusion, I submitted my views to Mr. Deshayes, Mr. Salter, and others, who seemed to consider that this mode of compromising the difficulty could not reasonably be objected to by the two authors principally concerned nor by the generality of Paleontologists." Op. cit., p. 86.

Afterward this classification was strongly objected to by several naturalists, who maintained that McCoy had "originally and positively" applied the name *Athyris* to the *S. concentrica* group, and, therefore, it could not be transferred to the other principal section. He, therefore, in the French edition of this introduction (1856), abandoned his first arrangement,* and substituted *Merista* and *Athyris*, at the same time transferring the latter to *Spirigera*, as in the extract given in the note below. (Op. cit., p. 101.)

Upon a careful examination of all the circumstances I think it will be found that according to the laws of nomenclature this change cannot be sustained. I shall therefore quote some of those laws and endeavor to apply them to this case.

The first rule reads thus:

"S. 1.—The name originally given by the founder of a group or the describer of a species, should be permanently retained, to the exclusion of all subsequent synonyms."

It seems scarcely necessary to quote such a rule as this. I only do so in order to make the comment, that it is the most important of all the laws of nomenclature; and that its operation cannot be prevented in any case, by merely technical objections or by any error in the details of a generic or specific description. Provided the original diagnosis contains sufficient in substance, to enable the scientific public to identify the group, trivial errors, from which the writings of no naturalist are free,

* "Mais ce moyen terme a été critiqué par plusieurs naturalistes qui ont insisté sur ce que le terme *Athyris* avait été originairement et positivement appliqué par son auteur a la *T. concentrica* et sur l'impropriété de l'autre dénomination pour désigner des coquelles telles que les *T. tumida*, *Herculea*, &c. M. Suess nous a informé (2) qu'il avait, en 1851, proposé le nom de *Merista* (3) pour le groupe renferment ces derniers. J'abandonne donc la proposition que j'avais faite en 1853, et je conserve indifféremment l'*Athyris* McCoy, ou le *Spirigera* d'Orb., pour le *T. concentrica*; et *Merista*, Suess, pour les *T. tumida*, *Herculea*, *etc.* (2) *Neues Jahrbuch*, p. 62, janvier, 1854. (3) *Jahrb. k. k. geol. Reichsanstalt*, II, IV, 150, 1851. Mentionné encore dans *Leonhard's neues Jahrbuch*, p. 127, 1854."

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will not have any effect. All that can be done is to rectify; not to destroy. One of the exceptions to this rule is thus expressed in No. 11. "A name may be changed when it implies a false proposition which is likely to propagate important errors."

According to this exception if the name *Athyris* should be applied to the *S. concentrica* group there is a possibility of its falling into the list of synonyms; for, although no very important error would be superinduced, yet few naturalists can apply it to shells with a well defined foramen without feeling that such an application is to some extent, inconsistent with the purity of scientific nomenclature.

"§ 3.—A generic name, when once established, should never be cancelled in any subsequent subdivision of the group, but retained in a restricted sense for one of the constituent portions."

"4.—A generic name should always be retained for that portion of the original genus which was considered typical by the author."

This latter rule is preceded by some introductory observations which should be embodied in it as they in fact form a part of the rule itself. They are especially applicable to this case.

"When a genus is subdivided into other genera, the original name should be retained for that portion of it *as at first defined*. Authors frequently indicate this by selecting some one species as a fixed point of reference, which they term the "type of the genus." When they omit doing so, it may still in many cases be justly inferred that the *first* species mentioned on the list, *if found accurately to agree with their definition*, was regarded by them as the type. A specific name, or its synonyms, will also often serve to point out the particular species which by implication must be regarded as the original type of the genus. In such cases we are justified in restoring the name of the old genus to its typical signification, even when later authors have done otherwise."

Now this rule bears directly on the question, because many naturalists are under the impression that the first species placed on the list must *necessarily* be regarded as the type, where the author is silent on that point. But according to the above (and common sense), it is only so if found *accurately to agree with the definition*. *Spirigera concentrica* does not agree either with the name *Athyris*, nor with McCoy's generic description, nor with his typical figure. Therefore it cannot be arbitrarily selected as the type, and the name *Athyris*, in consequence, retained for that group. Indeed in many instances it would be impossible that the first species placed in the genus should be the type, for the author might not have the true type in the collection under investigation.

In this instance, as before mentioned, McCoy was preparing a work exclusively devoted to Carboniferous fossils, among

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which *A. tumida* does not occur. In preparing his description of the genus he may, however, have had that species before him, and its imperforate beak may have had some influence.

§ 5. "When the evidence as to the original type is not clear and indisputable, then the person who first subdivides the genus may affix the original name to any portion of it at his discretion, *and no later author has a right to transfer that name to any other part of the original genus.*"

This last paragraph applies as well to the author who first subdivided the genus as to others. Once a genus is established, or subdivided, on sound principles, it becomes the property of science, and the author himself (either of the genus or the subdivision) can make no change. He may amend by striking out the errors, if any there be, but all that is true must remain.

I think that on a careful study of all the circumstances, it will be perceived that Mr. Davidson's first adjustment of this question was the most wise, the best for the interests of science, and the most just toward all the parties concerned, that could be devised. It was not inconsistent with the laws of nomenclature, but in perfect accordance with them in every particular; and, therefore, should be retained.

In one respect, however, it has been modified. *Athyris* as first defined by him, included *Merista* of Prof. Suess. This was, no doubt, due to the fact that the characters of this last named genus were not then accurately known to the scientific public. This makes little difference. *Merista* has long since been separated, with its type *M. Herculea;* leaving the other and most important group for *Athyris* with *A. tumida* for the type.

With regard to *Spirigera*, I think it can also be retained notwithstanding the following rule:—

§ "When two authors define and name the same genus, *both making it exactly of the same extent*, the latter name should be cancelled *in toto*, and not retained in a modified sense."

If the name *Athyris* had been extremely objectionable, according to the 11th rule, *Spirigera* might have cancelled it altogether. But the true principle of interpreting these laws is, that where there is any possibility at all of saving the original name it must be saved, even if the rules be strained to their utmost in that direction. The rules cannot be stretched to destroy; but they may be strongly bent in the other direction, to preserve. If a generic name should be appropriate for a large number of the species of the group to which it was originally applied, and *not very* objectionable as to a few only, I doubt that it can be changed. Such was the case with *Athyris* when D'Orbigny objected to it. More than two-thirds of the species designated by him are imperforate, and he should have retained the name for these. Some naturalists were, therefore, in favor

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of rejecting *Spirigera* altogether; others of retaining it. It is not, therefore, a case clearly within the rule; and as there was much doubt, the best course to take, as soon as it was found possible to do so, was taken by Mr. Davidson. He decided in favor of preserving the name.

3. *Authors who have adopted the classification.*—In 1856, Professors H. G. Bronn and F. Roemer, in the third edition of Bronn's *Lethæa Geognostica* adopted Davidson's classification and copied his diagnosis of both genera in full. They cited *A. tumida* as the type of *Athyris*. "Die typische Art ist *Athyris tumida* McCoy. (*Atrypa tumida* Dalman.) Andere Arten sind *A. Herculea* (*Terebratula Herculea* Barrande), *A. pseudo-scalprum* (*Terebratula pseudo-scalprum* Barrande), *A. scalprum* (*Terebratula scalprum* Fred. Roemer)." Op. cit., p. 331.

They also recognized *S. concentrica* as the type of *Spirigera*. "Die typische Art ist *Sp. concentrica* (*Terebratula concentrica* Bronn). Andere Arten sind *Sp. pectinifera* (*Atrypa pectinifera* Sowerby), aus dem Zechstein, *Sp. Roissyi*, (Sp. de Roissyi Leveillé)," &c., Op. cit., p. 332.

In the same year Eichwald placed *A. tumida* in *Athyris* and *S. concentrica* in *Spirigera*.*

In 1860 he also introduced the same classification in his great work on the Paleontology of Russia. The Russian species are *A. tumida*, *didyma*, *ungula*, *cassidea*, *S. concentrica* and *ambigua*.†

In my studies of the Canadian Brachiopoda I had no occasion to describe any species of this group until 1859, when I commenced a series of papers on the Devonian Fossils of Canada West. At that time I had not fully investigated the subject, but understood from a paper published by Mr. Davidson in the "Geologist" (vol. 1, 456), and also from Woodward's "Manual of the Mollusca" (p. 223), that *A. tumida* and *S. concentrica* were thought to be inseparable.‡ Not feeling perfectly satisfied that this was the correct classification, I prefaced my descriptions with the following remarks:—

Genus ATHYRIS,—McCoy.

"There is much difference of opinion as to the propriety of retaining this generic name. It implies that the shells have no foramen in the ventral valve, and yet many are placed in the genus which have the beak distinctly perforated. Some paleontologists are, therefore, in favor of using D'Orbigny's appellation *Spirigera* instead of *Athyris*. Nearly all of the Silurian species, and some of those from the Devonian rocks, have the beak so strongly incurved, that no foramen can be seen. For such, at

* Beitrag zur geographischen Verbreitung der fossilen Thiere Russlands. Bull. Soc. imp. Nat. Moscou, vol. xxix, pp. 419, 422.

† *Lethæa Rossica*, vol. ii, p. 731 (*Athyris*); p. 735 (*Spirigera*).

‡ In this work Mr. Woodward separates *Merista* (although with doubt) as a subgenus, and refers *A. tumida* to *Athyris*.

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least, the name *Athyris* does not appear to be very inappropriate. Mr. Davidson still retains it, not only for those which have the foramen concealed, but also for those with it open. It appears probable that the genus will sooner or later be sub-divided, and in that case *Athyris* might be retained for the species with closely incurved beak, and *Spirigera* for some of the others. I shall give some account of the generic characters of this group of shells in another article. The following species are placed in the genus provisionally."—*Canadian Journal*, [2], vol. v, p. 273, May, 1860.

In that paper I described two species with closed beaks, *A. clara* and *A. Maia*, which, no doubt, belong to the genus. The others with perforated beaks, I marked doubtful, thus:—A. (?) *scitula* (Hall); A. (?) *Clusia*, n. sp.; A. (?) *unisulcata* (Conrad); A. (?) *rostrata* (Hall); A. (?) *Chlöe*, n. sp.*

I think it the same as the species called *Meristella Doris* by Prof. Hall (13th Reg. Rep., p. 84, 1860). I doubt that any of the others belong to either *Athyris* or *Spirigera*.

Afterward Prof. Hall (13th Reg. Rep., p. 74) proposed to establish a new genus *Meristella*, precisely identical with *Athyris*, as re-defined by McCoy, in 1852. His diagnosis reads thus:—

"Shells variable in form, oval, ovoid, orbicular or transverse. Valves unequally convex, with or without a median fold and sinus; beak of the ventral valve apparently imperforate, incurved over the beak of the smaller valve; area none; valves articulating by teeth and sockets. Surface smooth, or with fine concentric lines of growth and fine obsolete radiating striæ, which are usually more conspicuous in the exfoliated shell. The interior of the dorsal valve is marked by the presence of the longitudinal septum, and the upper part of the ventral valve by a deep subtriangular muscular impression which unites with the rostral cavity."

Now I hold that instead of proposing a new genus, he should have retained the original name *Athyris;* because his proposition amounts to a subdivision of the group, and according to the laws of nomenclature he should have applied the old name to that portion for which it is most appropriate, as had been done six years before by Davidson. As soon as this new arrangement was published, I re-investigated the subject; and perceiving that it amounted to nothing more than a restoration of Davidson's

* I now think that *A. clara* is the same as Prof. Hall's *Meristella nasuta*, but am not quite sure that it is Conrad's species. *A.* (?) *scitula* was afterward found to belong to a new genus described by me under the name of *Charionella*. (Op. cit., vol. vi, p. 148, March, 1861). It is not *Atrypa scitula* Hall, a point on which I was not certain at the time, as will be seen by the description, which reads thus:—

"The above figures represent different views of two specimens of a species which appears to me to be identical with that figured in the work above cited. It varies greatly in size. The length of the largest specimen that I have seen is seventeen lines, the greatest width fourteen lines, depth eight lines. The smallest is about two lines in length and many of intermediate sizes have been observed to make out the series. It is not certain that this species belongs to the genus *Athyris*." Op. cit., p. 30.

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former classification, but with a change of names, I declined to adopt it. In all the publications of our Survey, in which species of this group are described or figured, *Athyris* is used instead of *Meristella*.

On the merits of this classification, a note in this Jour., II, xxxiii, 130, expresses the views advocated herein. The following is an extract therefrom:—

"This is the classification which the writer of the criticism maintains should be sustained, and we cannot see any reasonable objection to it. It is perfectly just toward both McCoy and D'Orbigny. It inflicts no injustice on any other author. It is not inconsistent with purity of zoological nomenclature, or in any way injurious to science. It does not require any modification in either of the original definitions. The typical species are central and dominant forms of two different groups of species which together form one larger general group. *Athyris*, under this arrangement, is the generic name of that group which has *A. tumida* for its type. *Spirigera* is a perfectly unexceptionable name for the other group, of which the typical form is *S. concentrica*. Prof. Hall's proposed genus *Meristella* is precisely identical with the genus *Athyris* in its restricted sense (as above explained), and cannot be admitted until some good reason is shown for setting aside Davidson's arrangement. It belongs to Prof. Hall to place this reason before the public in a clear and unsophisticated manner. If he succeed in maintaining his point, then he will establish a classification for this group of fossils far inferior to that proposed by Davidson. *Spirigera* must be suppressed, and *Athyris* must take its place, and thus stand as the generic appellation of a group of fossils for which it is not appropriate. We hold that this change is not necessary, and as it would, if adopted, be injurious to science by affecting the purity of zoological nomenclature, it cannot be maintained."

ART. VII.—*Experiments on Itacolumite, (Articulite), with the explanation of its flexibility and its relation to the formation of the Diamond;* by CHARLES M. WETHERILL, Ph.D., M.D., Professor of Chemistry in the Lehigh University.

THE rock which derives its name from the mountain Itacolumi in Brazil is certainly one of the most interesting with which we are acquainted. As the companion (probably the matrix) of the diamond, a study of its origin and nature might possibly solve the problem of the formation of that gem; and its flexible character is at such variance with our ordinary experience of the stability of rock, that it is wonderful to those even who are most familiar with it.

According to the authorities, itacolumite is a laminated quartz rock of the talcose series, owing its lamination to a little talc or mica (Dana), to which material its flexibility is also due (Dana,

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Percy and others). It occurs in extensive formations in Brazil, the Urals, and in the United States in Georgia, and in North Carolina, and appears particularly to accompany the diamond.

The specimens which I have examined are: 1st. A number of slabs of various size from Saraw Mt., Stokes Co., N. C., given to me by Captain Samuel W. Dewey. 2d. Small fragments of a large slab in the Museum of the Smithsonian Institution, to which it was presented by Charles DeSelding, who obtained it in Rio de Janeiro, its locality being Minas Geraes, the celebrated diamond region of Brazil. These two specimens have the same general appearance; with the exception of color, which for the North Carolina rock is a light yellow, and for the Brazilian mineral a light reddish brown, and of the granular condition, which is finer for the North Carolina specimen.

They may be split more readily in one direction yielding slabs, and there are occasionally small fissures at right angles to these layers. There is also in one of my specimens a plane forming an angle of 15° with the plane of readiest cleavage and perpendicular to the planes of the fissures. It appears to be a joint and is covered with small crystals of quartz.

Scattered through the rock are small scales of mica which are comparatively few in number but of uniform size, thin, and determine the cleavage of the rock. These plates lie in parallel planes, as they would settle naturally from a liquid. Where they are abundant in any plane the rock splits there readily. If a piece of the itacolumite, thus split, be rubbed down perpendicularly to the cleavage plane, no scales of mica are perceived upon this new surface, because the observer is looking at the edges of the micaceous plates, but the lamellar nature of the rock is thus made very apparent.

The chief constituent of the rock under the microscope is quartz in very sharply fractured and fine grains, together with a little mica. Occasionally are to be seen very minute black grains. One specimen when rubbed down shows small pieces of compact white quartz, giving it the appearance of a section of sausage. The specific gravity of the North Carolina specimen, taken in the ordinary manner, is 2·61; but 2·69 after freeing its pores from air by a vacuum [sp. gr. of quartz 2·65]. The analysis yields the following results:

Vol. at red heat (water),	0·17
Silica,	95·89
Sesquioxyd iron,	2·78
Lime,	0·84
	99·68

Besides which, the qualitative analysis yielded traces of KO, NaO, MnO, MgO; but no Al_2O_3. The ferric oxyd, obtained

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also by attacking another portion of mineral by hydrofluoric acid, was 2·03 p. c. The iron is not distributed very uniformly through the rock, as may be readily seen by an inspection of specimens.

I found it impossible to separate completely the mica from the quartz by edulcoration. When the result of the washing is examined with the microscope, scales of mica are seen, generally colorless, but sometimes dark brown, and all polarizing light, as do also the grains of quartz.

This fine edulcorate when heated on platinum foil B.B. cakes together slightly, and a slight dust adhering to the platinum does not fairly melt but exhibits signs of intumescence. With salt of phosphorus very fine grains of silica are seen floating in the bead. With borax a clear glass without intumescence results. An experiment for HFl with the itacolumite mica yielding negative results.

The mica examined with the spectroscope gave the reactions of KO and NaO only. No different result was obtained after the mineral had been attacked by liquid hydrofluoric acid, and the residue evaporated to dryness with sulphuric acid before exposure to the flame.

The relative hardness of the siliceous grains in the mineral appears to be that of agate which may be scratched slightly by them. On one occasion the bottom of an agate mortar received a very decided scratch which gave color to the supposition of a minute diamond as the cause. The rock is quite porous when compared with other sandstones; water placed in an excavation will filter very readily through the stone, even in a direction perpendicular to the plane of stratification. Gases diffuse very easily through these pores; if a slab of the itacolumite one quarter of an inch in thickness, be cemented to the top of a glass cylinder, which is then filled with hydrogen, water rises very rapidly into the tube.

When the mineral is raised to a red heat, it acquires a red color when cool; when plunged hot into water it does not become more friable. Under the HO flame it fuses to a nearly colorless glass. Heating to redness does not impair the flexibility of the stone.

The specimen from Brazil was not analyzed. It presented the same physical character as the North Carolina mineral. Its color was different, being reddish brown.

In the Brazil sandstone, the siliceous grains are larger. To the eye the quantitative relation of the silica to the mica is the same for both specimens; if there be any difference, it is in favor of a somewhat larger proportion of *mica* in the Brazilian itacolumites.

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Explanation of the flexibility.—The flexibility of this rock is attributed universally to the mica which it contains, an inference which the microscope shows to be unwarranted. This flexibility is due to *small and innumerable ball and socket joints,* which exist throughout the mass of the stone very uniformly. Each joint permits a slight movement which is always greater in one direction. The accumulation of joints suffers a limited motion in every direction. This mobility is not perceptible in thick slabs unless they are large as to their other two dimensions. From such a slab it is easy to obtain a small and thin piece in which the flexibility may be observed; and the thinner the section the greater is the motion. Where small joints or fissures occur, the motion is greater at those points.

This jointed structure is so wonderful that it would warrant the name "articulite" to be given to the mineral, especially if we should find it again in other sandstones by observing them in very thin slabs.

To determine the nature of the motion, at first, various thin sections of the stone were taken, cut in three directions, viz: one parallel to the plane of stratification, one perpendicular to this plane, and one perpendicular to each of the above planes.

The sections were made by cementing layers of the rock upon a glass slide with shellac, rubbing down to the required thinness upon a slab of the itacolumite, and removing the resin by alcohol.

These sections were fastened to a piece of cork in such a manner that they might be moved, and the motion observed under the microscope. The sections behaved alike and the play of the joints was at once seen. I subsequently found that thin sections were not at all needed for this purpose, since the articulations may be perceived with the microscope in any fragment of the mineral. A piece is fastened to the stage, which is then inverted and slightly tapped to remove any loose grains of sand. Upon adjusting the instrument and touching the specimen gently with a quill point, it is perceived to be composed of small botrioidal masses or congeries of grains of sand. The observer can scarcely divest himself of the impression that he sees a loose layer of sand, until the stage is again inverted and jarred, which demonstrates that the grains are interlocked. By managing the reflected light, with which the object is illuminated, the plates of mica can be distinctly seen; they are very few in number, and *take no part whatever in determining the motion.* The articulation is *not* that of basaltic columns. The component grains are arranged so that most of the groups have cavities and projections, and so that the projection of one group engages in the cavity of its neighbor.

By observing the thin edge of the specimen regular cavities

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are seen, out of which groups of sand particles have fallen. The rock may even be dissected by the needle point and shown to be made up of such congeries, and the groups may also be resolved into their constituent grains.

The millimetric length and breadth of the groups varies from $0{\cdot}26 \times 0{\cdot}26$ to $0{\cdot}26 \times 0{\cdot}32$, and the size of the individual grains composing the groups averages between $(0{\cdot}026)^2$ to $(0{\cdot}04)^2$ mm.

Many are as large as $(0{\cdot}08)^2$ and some as small as $(0{\cdot}013)^2$. The general cubic capacity of a group or grain could be determined by multiplying the above areas by one of the linear dimensions given.

Each group appears to be composed of from 20 to 50 grains of sand not very strongly agglutinated. The individual grains are very "sharp" fragments of silica, not flat plates, and of great uniformity with respect to size.

The scales of mica are flat and nearly square fragments. They average in area $(0{\cdot}08)^2$ mm. and vary from $(0{\cdot}26)^2$ to $(0{\cdot}065)^2$ mm.

The Brazil mineral presents almost exactly the same character under the microscope as that from North Carolina, with the exception that the individual grains, as well as the congeries, are somewhat larger in the former. The oxyd of iron in the mineral is not the *cement* by which the grains are united, for a thin section of the rock boiled in HCl for five hours did not become more friable. The cement would appear rather to be siliceous (hydrated silica); because a piece boiled in a solution of caustic soda becomes partially disintegrated, especially at the edges, and is much more friable as to its mass.

When dilute solution of hydrofluoric acid is poured upon a thin section it is immediately resolved into grains, affording a complete disintegration of the section.

The flexibility of the itacolumite (N. C.) is shown in a striking manner with a cylindrical piece sawed out from a thick slab of the sandstone and rubbed down upon another piece to the required shape. The planes of stratification were taken parallel with the cylinder's axis.

The specimen measures 198 mm. ($7\frac{3}{4}$ in.) by 13 mm. ($\frac{1}{2}$ in.) in diameter. It can be compressed and elongated in the direction of its axis, the extent of the motion being a little over $\frac{1}{2}$ mm. When one end is fixed, the other end may describe a circle of 34 mm. ($1\frac{3}{8}$ in.) diameter, and may be made to touch every point in the area of the approximate spherical zone. The rod can also be twisted about its axis, the torsion being 10°.

Catenary.—When the rod is supported upon two nails 185 mm. apart, it assumes the form of a curve very like the catenary. The greatest deflection from the line joining the points of support varies from 3 to $3\frac{1}{2}$ mm. as the rod is rotated about its axis

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on the nails. My colleague and Prof. of Mathematics in the University, Col. E. W. Morgan, very kindly undertook the discussion of this curve with the following results. The curve was traced upon paper with a pencil under the stone resting upon two points of support at its extremities and the ordinates were measured for comparison with the ordinates of different curves.

Prof. Morgan at first compared with the circle, as the curvature was so slight, but it departed sensibly from that curve in such a manner as a true catenary would do. He then compared it with a loaded catenary (which is a parabola) with similar results. The beam loaded with equidistant equal weights (ellipse) was next essayed but the curve did not agree with it. Nor did it coincide with the true catenary. It was nearer to the loaded catenary than to any known curve. The result therefore of the calculation indicated that the curve of the stone lay between the catenary and the ellipse.

Prof. Morgan next prepared an experiment with a small beam of white pine loaded with equal equidistant weights for the ellipse, with a fine and flexible gold chain for the catenary, and with the stone cylinder. These were placed upon the same supports (185 mm. apart) and so arranged that the greatest deflection for each curve should be to the same point.

Upon comparing the chain with the loaded beam it was evident that the latter curve was a true ellipse, and consequently the comparison would be attended with no uncertainty due to a supposed defect in the slip of pine. The chain and stone were compared next, and then the stone and beam. Although the experiment was not of a character to afford very delicate measurements, it showed with great clearness that the curve of the stone is very nearly a catenary, and that it lies between this curve and the ellipse.

This result which was not anticipated by either of us, for we expected that the curve would prove to be a catenary, is very interesting and agrees with the jointed condition of the stone, as well as with the character of the joints shown by the microscope.

In a flexed beam the forces are partly compressive and partly tensile, as we consider the upper or the lower portions of the beam, and when the beam is loaded with equidistant equal weights, the conflict of these forces causes the beam to assume the form of the ellipse. The itacolumite cylinder takes the catenary form by reason of its ball and socket joints. But the rod has a definite thickness and a *series* of joints parallel with its axis, in this respect unlike a true chain. Furthermore, as the microscope shows, the sockets are *rough*, as they are formed by grains of sand, and the protuberances fitting into them are also rough. Consequently, when the stone bends by its weight between the

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supports there is a compressive action toward the top, and a tensile one along the bottom of the cylinder, as in the case of a beam, and this gives an elliptical character to the curve. As the diameter of the rod increased or diminished, I should expect to find the curve of the stone approach the ellipse or the true catenary.

The relation of itacolumite to the diamond.—The most interesting relation of this rock is to the diamond which it accompanies. This gem, found at first in the "gurgulho" or disintegrated rock, has at length been discovered *in situ* in the itacolumite itself; thus showing that this sandstone is at least one of the sources of the diamond.

The physical conditions which have led to the peculiar jointed character of the itacolumite may have had an important bearing upon the crystallization of the diamond, and hence it is of interest to ascertain what those conditions were, with the hope of throwing light upon the origin of the gem.

I confess to be at a loss to offer a very reasonable hypothesis with respect to these conditions. It is difficult to see why the siliceous fragments cohere to form definite groups or congeries. If we suppose that planes having a certain relation to the crystalline axes cohere by long continued contact more readily than planes having a different relation, why does this partial cohesion occur with such surprising regularity; why also is it not perceived in other sandstones? It would appear that the sand which formed this rock contained something diffused in a regular manner (and which was subsequently removed), which prevented the uniform contact of the siliceous grains. It is possible to conceive that *petroleum* might have that effect when added to sand of a certain degree of moistness, forming a kind of emulsion, and that the petroleum was afterward slowly removed by a process which permitted a crystallization of a portion of its carbon. When water was dropped upon dry sand, the mixture when stirred, formed lumps of uniform size; if, before stirring, a little petroleum was added, the lumps appeared to form more readily. The lumps are left out of aqueous contact by the coating of petroleum around each one, while the siliceous particles forming the lumps have water between their component grains. Cohesion could take place between the particles, but not between the lumps. Under the microscope the sand thus treated bears a striking resemblance to itacolumite.

I made this supposition before acquaintance with DeChancourtois's hypothesis that the diamond may have been formed from hydrocarbons, and that its origin is thus connected with the existence of petroleum-bearing schists. My hypothesis therefore receives a certain support from the views of DeChancourtois.

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I have heated several of my specimens of itacolumite to ascertain whether any petroleum odor was evolved, but with negative results. If the diamond proceeded from a slow and gradual oxydation of the hydrocarbon perhaps we should not expect to find any petroleum left.

In this connection the small and rarely occurring black specks, seen with the microscope, are to be noted; are they minute black diamonds, and have they any relation to the experiment where the agate mortar was so deeply scratched?

Bethlehem, Pennsylvania, April 6.

ART. VIII.—*On the Laws which govern the general distribution of Heat over the Earth;* and on Brewster's Neutral Point;* by PLINY EARLE CHASE.

1. *The laws which govern the distribution of heat.*

THE principal elements of general thermometric variation are: 1, the heat imparted by the sun; 2, terrestrial absorption and radiation; 3, atmospheric currents. Of these three agencies, the first is, in one sense at least, the chief, since it is the one on which the others depend; the second is mainly instrumental in modifying the other two, and especially in retarding the daily and yearly changes; the third is a subject of hourly experience, and its meteorological importance is now generally recognized.

The amount of heat which is received directly from the sun, evidently varies as the cosine of the zenith distance, or the sine of the sun's altitude. In the daily distribution of temperature this is the most important element, as is evident from the tabular comparisons in my communication of Sept. 21, 1866.† Absorption and radiation proceed at nearly uniform rates, therefore it may be assumed that their effects are approximately proportional to the time during which they operate. The average general variation which is due to the influence of the winds is a difficult point to determine, but the present investigation has led me to believe that it may be measured by the difference of *arc* (instead of the *sine*-difference) of the sun's meridian altitude. My reasons for this inference are the following: 1, the general average temperature of the year often appears to vary very nearly as the arc in question; 2, it seems unreasonable to suppose that a variation of this character can be attributable either to the heat communicated by the sun or to terrestrial absorption and radiation; 3, the tendency of the air, so far as it is deter-

* Abridged from the Proceedings of the Am. Philosophical Society, Feb. 1, 1867.

† Proc. Amer. Phil. Soc., vol. x, pp. 261–269. See, especially, the observations at St. Bernard, and the general average of Table I, p. 267.

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mined by the direct heat of the sun, is at all times toward that point of the earth's surface at which the sun is vertical, and we may readily believe that that tendency should be proportional to the distance, measured on a great circle of the earth, through which the air would be obliged to move in order to reach the sub-solar point. This distance evidently varies as the *arc* of the sun's zenith-distance.

We have, then, three natural standards for admeasurement, by means of which, if we rightly eliminate special and limited perturbations, we may perhaps be able to determine the predominating influence, in many cases both of local and of general thermal disturbance. In order to institute as broad a comparison as possible, I have adopted a method of elimination which may be illustrated by a single example.

The average monthly temperatures of the United States, as deduced from Prof. Coffin's reductions, appear to be as follows:

Jan. 28·352	Feb. 30·873	Mar. 39·049	Apr. 49·744	May 60·902	June 69·780
July 75·640	Aug. 71·754	Sept. 65·643	Oct. 53·922	Nov. 42·350	Dec. 32·132

Averaging the temperature at equal intervals from January (taking the mean temperature of Dec. and Feb., of Nov. and March, &c.), we get the following results.

Months from Jan.	0	1	2	3	4	5	6
Average temp.	28·352	31·502	40·699	51·833	63·272	70·767	75·640
Monthly diff.	....	3·150	12·347	23·481	34·920	42·425	47·288
Ratio of do.	....	·067	·261	·497	·738	·897	1·000
Ratio of diff. of zenith distance,	....	·069	·255	·500	·745	·931	1·000

The second of the above series of ratios (that of the differences in the arcs of the sun's zenith-distance) is based upon the following estimate of the average monthly increase of solar altitude at all places in the temperate zones.

Mos. from winter solstice,	1	2	3	4	5	6
Increase of solar altitude,	$3\frac{1}{4}°$	12°	$23\frac{1}{2}°$	35°	$43\frac{1}{4}°$	47°
Ratio of increase,	·069	·255	·500	·745	·931	1·000

If we allow about 24 days for the cumulative effects of increasing heat and cold, these ratios become properly comparable with the monthly ratios of temperature-variation, as in the following table, which is compiled from the works of Dove and Guyot.

Diff. of time, mos.	1	2	3	4	5	6
Ratios of sines,	·076	·284	·545	·784	·946	1·
" " arcs,	·069	·255	·500	·745	·931	1·
N. Hemisphere,	·076	·259	·512	·753	·935	1·
S. Hemisphere,	·077	·281	·538	·763	·938	1·
Arctic region,	·071	·231	·479	·733	·934	1·
Europe,	·069	·239	·501	·738	·938	1·
Asia,	·097	·274	·535	·769	·934	1·
N. America,	·055	·279	·494	·741	·917	1·
S. America,	·077	·275	·501	·724	·936	1·
Africa,	·088	·267	·537	·761	·938	1·
Australia,	·081	·313	·618	·801	·913	1·

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An extensive series of comparisons* seems to warrant the following inferences, all of which are confirmed by other considerations.

1. Taking into view the entire land surface of the globe and the entire range of the year, the direct heat of the sun and the induced aerial currents appear to be about equally instrumental in determining fluctuations of temperature.

2. The influence of the winds is most marked in the Northern and Western hemispheres; that of solar obliquity, in the Southern and Eastern hemispheres.

3. Where the sun's rays are least intense (as in the Polar Regions) and where the winds are most variable, the ratios exhibit the nearest parallelism to the increments of arc; but where the winds are most uniform (in and near the region of monsoons), they correspond more closely with the sinal increments.

4. The general changes of temperature at midwinter, and at the equinoctial seasons (when the sun's declination is changing most rapidly), are most dependent upon the local solar heat; the midsummer changes are more subject to the influence of the winds.

5. The greatest conflict of opposing forces occurs during the sun's passage between the comparatively wind-governed Northern hemisphere and the sun-governed Southern hemisphere. This conflict is manifested in the spring and autumn rains.

6. The closest and most general approximation of ratios is shown in the monthly temperature change at midsummer, which corresponds almost precisely with the change of arc.

2. *On Brewster's Neutral Point.*

In the April number of the Philosophical Magazine, Sir David Brewster says: "Dr. Rubenson has never been able to see, even under the fine sky of Italy, the neutral point which I discovered under the sun, and which, I believe, has never been seen by any other observer than Mr. Babinet."

The point is question can be easily seen in Philadelphia on any clear day, when the sun is more than 20° above the horizon, and I have reason to believe that it can be found with equal ease at many other places in the United States, although I have not been able to find any published observations except my own.†

As all the phenomena of skylight polarization are very interesting, and as some of its laws are still imperfectly understood, others may, perhaps, be induced to turn their attention in this direction, so as to determine whether the difficulty experienced by European observers is owing to a higher latitude, to a moister atmosphere, or to some other cause.

* See Proceedings, &c., loc. cit.

† Proc. Amer. Phil. Soc., vol. x; this Journal, vol. xlii, pp. 111, 112.

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A simple Savart polariscope is sufficient for making the observations. In positing Brewster's neutral point, I have usually raised the lower sash of an attic window so that the bottom of the sash will screen the sun from the polariscope. I have thus been able, in every instance when the atmospheric conditions seemed favorable, to see very distinctly the neutral point, and the oppositely polarized bands above and below.

ART. IX.—*Contributions toward a Theory of Photo-chemistry;* by M. CAREY LEA.

IN a somewhat extended series of experiments published at various times,* I endeavored to fix, as far as I was able, some of the facts of photo-chemistry, and more especially the nature of the action of light upon iodid of silver, at once the most important and the most difficult of explanation of all the facts of photo-chemistry which fall under our notice. The phenomena exhibited by iodid of silver, in the point of view which they assume to me, are the key to the whole matter, and based upon them, I propose to offer some theoretical views upon the general subject.

The study of light has always been largely aided by analogical reasoning from another source—that of sound, whose phenomena probably afforded the first conception of the undulatory theory, and in turn, discoveries made in light have aided our knowledge of the phenomena of heat, many of which would perhaps have been still unknown but for the aid so obtained. It is therefore perfectly allowable to reason analogically back from heat to light.

The tendency of heat is always to equalize itself, by radiation and conduction. The loss of heat in this way where the body affected is much above the temperature of those that surround it is enormously rapid, and this loss continues with diminishing rapidity till an equilibrium is attained.

The same is the case with light, though the loss is there usually so much more rapid as to be almost simultaneous with the reception, to our senses, and in the ordinary conditions of observation it is quite so. But the exceptions are perfectly well marked. The phenomena of *phosphorescence* show that a body may retain the impression of light for a considerable time. And the phenomena of phosphorescence received an immense extension from the ingenious and beautiful experiments of Becquerel,

* A brief résumé of many of these experiments was published in this Journal in the year 1866.

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who showed that a very large number of bodies continued to emit light for an appreciable time after the direct influence of light ceased to operate upon them. Although the time might be but a very small fraction of a second, still it was rendered brilliantly evident to the sense, and the exact period could be measured. And when we consider the enormous rapidity with which the phenomena of light take place, even the fraction of a second is a long time, and it would be exceedingly rash to attempt to limit such phenomena to our powers of observation.

Just as with heat there exists in all probability an absolute zero at which heat-vibrations cease, so probably there is a light zero at which the body ceases to vibrate luminously. Most bodies (to our perception) reach this zero immediately when carried into darkness. Phosphorescent bodies, form, however, a striking exception.

Let us suppose that a body be surrounded by other bodies equally illuminated, and that temporarily an additional quantity of light falls upon it. On the cessation of this illumination, the body will recover its condition of equilibrium with surrounding bodies, by losing its excess of light in the following manner: 1. By reflection. 2. By transmission. 3. By conversion into heat. 4. By chemical action. 5. By radiation.

That is, the body, if it be transparent, or have reflecting surfaces, will part with a certain quantity of its light in those ways. If it is susceptible of chemical decomposition, a certain portion of light will be consumed in effecting that decomposition. And what farther loss is necessary to take place in order to reach an equilibrium, must take place by conversion into heat and by radiation. As we have already seen, this radiation may be either instantaneous, as in the case of most bodies, or it may require minutes, hours, or even days, as in the case of phosphorescent bodies. This fact is of the utmost importance in the attempt I here make to explain the phenomena of photo-chemistry.

In their influence upon combustion and decomposition, the phenomena of light and heat exhibit a striking parallelism. Each tends in some cases, to promote combination, but in the vast majority of cases, to dissociate elements already combined. Such especially is the action of light in the cases which I propose to consider.

I have shown elsewhere, that, contrary to long-established opinion, perfectly pure iodid of silver, isolated from all other substances, is sensitive to light, and this fact, now I believe universally admitted, must form the corner-stone of photo-chemistry. For iodid of silver is precisely the only substance fitted to give us a clear view into the action of light upon matter in general, by which I mean that this action is so much more evi-

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dent and appreciable in the case of iodid of silver, that we may thence obtain views subsequently to receive a wide extension.

Now when pure iodid of silver is exposed to light, it changes slightly in color, and has acquired a new property, that of attracting to itself a metallic precipitate in the act of forming, or a metallic vapor already formed. Some have seen in this action of light upon the iodid, a distinct reduction to sub-iodid. But of this, proof is altogether wanting. An extension of the exposure many million fold does not produce a reduction appreciable by the most delicate reagents, and I have been enabled to prove that such iodid perfectly recovers its sensibility in the dark. That is, a film of such iodid, exposed for many hours to a bright sun does not further darken beyond the change produced by the first instants of diffuse light. And if then put aside in the dark for a brief time it re-acquires the capacity by exposure for a second, to receive an image.

But if, during this exposure, or subsequent to it, a body capable of combining with iodine be brought into contact with it, a true chemical decomposition takes place. The silver loses half of its iodine, is reduced to sub-iodid, and a vapor, or a precipitate, under favorable circumstances, is attracted to the parts so acted upon.

What then is the nature of this change, this impression, received in a second, and then slowly passing spontaneously away? Evidently a physical, not a chemical change, though leading the way to a chemical change. But what is that physical change?

When light falls upon a compound body, its molecules are made to vibrate, and if that vibration be carried to a certain violence, the excursions of its atoms may exceed the limit which their affinity permits, and the compound will be torn asunder. We have an exact analogue of this in sound. A thin glass vessel, if a certain note be sounded near it with sufficient force, will be shattered, the excursion of its atoms exceeding the limits imposed by its attraction of cohesion. Vessels of other materials would resist this and much greater strain. Just so with light. Some bodies will be decomposed, others will resist. So when pure *chlorid of silver* is exposed to the light, it presently assumes a violet color, losing at the same time one-half of its chlorine. On the other hand, when pure *iodid of silver* isolated, is exposed to light, no chemical change takes place. But the impression of light is for a time persistent. Now the analogy which exists between this effect and phosphorescence has not been before perceived. *The "physical" impression of light is a persistence of the invisible (or "chemical") rays exactly parallel to the persistence of visible or luminous rays, in phosphorescence.* The vibrations excited by light are in both cases not given out instantaneously

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as in most light-phenomena that pass under our notice, where the return to photo-equilibrium is immediate, but this equilibrium is only reached after the interval of hours or days.

Consequently, so long as these vibrations of non-luminous light (so to speak) continue, the body under their influence is much more exposed to suffer decomposition than when under normal influences. And if a film of such material has had parts exposed to light while other parts have been protected, and the whole be then exposed to influences provocative of decomposition, it is evident that those influences may be so graduated that they will tell only upon the parts predisposed by the impression they have received.

This function of light which I here endeavor to prove the existence of, may be conveniently termed *Actinescence.*

That this word does not express with entire accuracy what is intended to be conveyed, is sufficiently evident. But it has the advantage of connecting the phenomena with the parallel one of phosphorescence, and is perhaps on the whole as well suited as any other that could be found or made.

Where, through phosphorescence, a body temporarily retains, and subsequently emits light, that emission, in the gradual return to its photo-equilibrium, is rendered evident by the phenomena that usually accompany the emission of light. Surrounding objects are illuminated, faintly but visibly. Should we not therefore expect similar results in the case of actinescence?

Not only should we find them, but they have actually been described, though not understood. For in actinescence we have the explanation of the phenomena described by Niepce de St. Victor as the "storing up of light" (emmagasinement de la lumière). St. Victor showed that certain objects exposed to light and then carried into darkness had in some cases acquired the power of acting chemically upon other bodies with which they were placed in contact. His results were received at first with something like derision, and the facts, which could not be denied, were said to arise from some chemical decomposition which had taken place in the body during its exposure to light, generating reducing agents which were subsequently given off in the darkness.

But until now, the identity between the latent physical image and the storing up of light has not even been guessed at, still less the perfect parallelism between these phenomena and that of phosphorescence. That a body may immediately regain its equilibrium with respect to one sort of rays and slowly with respect to another, involves no difficulty whatever; we continually see this in the facts of common phosphorescence. Differ-

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ent phosphorescent bodies emit light of different colors. If one phosphorescent body emits a red, another a green, another a blue light, there is evidently no difficulty in conceiving that in others, the tendency to a slow recovery of equilibrium may belong to the still more refrangible and invisible rays of the spectrum. In fact this is so completely within the analogy of the subject that it would be surprising if it were not the case.

Viewed in this manner, the physical impression of light, as distinguished from the chemical, loses all its difficulty and mystery. A substance like iodid of silver is capable of decomposition by light, only when in contact with some substance having an affinity for iodine. But if exposed in an isolated condition, it becomes *actinescent*, it retains the disturbance occasioned by the light, and only gradually parts with that energy to surrounding objects. So long as any portion of this impression lasts, it is capable of undergoing decomposition if brought into contact with substances capable of taking up iodine from it.

Iodid of silver when exposed to light in a state of perfect purity and isolated from all other substances, undergoes no chemical change. Carried into darkness, it continues to vibrate in unison with the more highly refrangible rays, either those entirely beyond the visible spectrum, or else those having a very low illuminating power, and this in so faint a degree that no phosphorescence is visible. If it now be brought into contact with any substance which would have occasioned decomposition in presence of light, then, so long as this phosphorescence of actinic rays, this *actinescence* continues, the same decomposition will take place. If simply left in darkness, this actinescence will, as I have already shown, gradually expend itself, precisely like ordinary phosphorescence. And also as in the case of ordinary phosphorescence, a fresh exposure to light will create a fresh impression, the iodid of silver having apparently perfectly recovered its original condition. With perfectly pure iodid of silver, twenty-four hours is sufficient to nearly obliterate the action of light, the actinescent power is exhausted, or nearly so, and the iodid can be exposed again. If this second exposure be made under a photographic negative, and an ordinary photographic developer is applied, a clear sharp image is obtained.

It seems worthy of remark that though no visible phosphorescence is noticeable in the case of iodid of silver, it is by no means impossible that if examined by the ingenious instrument constructed for Mr. Becquerel by Mr. Dubosc, a visible phosphorescence might also be observed. However this may be, it does not affect the principles here laid down.

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The general views here expressed will be found to throw light upon other obscure photo-chemical phenomena besides the latent physical image. Of these I shall briefly cite one.

If light fall upon a body decomposable by light, its energy will be expended in two directions. Part will be transmitted to surrounding objects, part will be expended in dissociating one or more of the elements of the body. As the intensity of the light increases, the amplitude of the excursions also increases, and a larger proportion will be expended in decomposition. It therefore follows that the decomposition effected will not be in the ratio of the intensity of the light, but will be greater in a strong light and less in a weak; that is, that a light of half strength acting for a double time, will not effect an equal amount of decomposition. Now this exactly accords with the universal experience of photographers who find that where media of unequal thickness are interposed between a sensitive surface and the light, as in the case of a negative superimposed upon chlorid of silver, the weaker the light the greater will be the contrast in the degrees of effect produced upon the different parts of the film; so much so that this is systematically adopted as a base of operation.

To enlarge farther here on the application of these principles, and the light they throw upon photographic phenomena, would, however, be inconsistent with the limits I have imposed upon myself. My object here has been to prove the existence of a well-marked but hitherto overlooked property of matter, and further to show the identity of this property with what in photo-chemistry has been vaguely described as the physical image.

This explanation of these obscure phenomena seems so simple and sufficient as scarcely to require proof. Nevertheless that proof is afforded by the reactions of iodid of silver, perhaps the most remarkable substance with which chemistry makes us acquainted. This theory rests upon two properties for whose existence I have long contended, and which I believe I have succeeded in establishing, namely, the *sensitiveness to light of iodid of silver even when perfectly isolated*, and its *spontaneous recovery of that sensitiveness* after obliteration through powerful action of light, by simply remaining in darkness. From these facts I deduce the conclusion that the latent image is simply due to a phosphorescence of chemical or actinic rays to which property I give the name of actinescence.

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ART. IX.—*Contribution to the Chemistry of Brines;* by CHARLES A. GOESSMANN, Ph.D.

ALL natural solutions of chlorid of sodium, which are used for the manufacture of salt, are more or less contaminated by various saline admixtures. The peculiar influence exerted by certain of these foreign compounds on the chemical composition, the form, and the general external appearance of the chlorid of sodium, during its separation as a commercial article, even under the same system of manufacture and with the same precautions, has occupied the attention of chemists from the earliest times in the history of this branch of chemical industry.

A classification of brines, for the purpose of aiding their investigation, had in the course of events become advisable; and among others, Karsten* at an early date, made some advances in this direction. In his valuable discussions upon brines he has adopted the following principle; the brines are divided into two classes; the *first* class includes all brines containing *chlorid of magnesium* and *sulphates;* and the *second* class those containing *chlorid of calcium* beside *chlorid of magnesium.*

He favored at that time, the volcanic theory, in regard to the origin of the rock salt (primitive deposits), a view long since discarded as a general rule, in favor of its marine origin. He considered it self-evident, that the brines, in every well investigated case could be proved to originate from the dissolving action of an underground fresh water current upon rock salt. Their differences in composition were ascribed,—leaving the concentration as to amount of salt dissolved entirely out of the question,—in regard both to quantity and to quality, to the peculiar nature and condition of the strata, which had intercepted their passage to the surface. According to his view, decaying pyrites, sulphates and chlorids of the metals and earths were the main cause of the contamination of these solutions of rock salt. The extent to which these compounds happened to be met with, decided ultimately the amount of foreign admixtures thus imparted, while their final quality and relative proportion was determined by the order of succession in which the contaminated brines chanced to traverse limestone rocks or dolomites. The gypsum present was considered in most cases to be the result of the reaction of soluble sulphates—particularly of the alkalies, of magnesia or of iron, upon chlorid of calcium; moreover, primary and secondary deposits of chlorid of sodium were admitted. The presence of chlorid of calcium consequently was looked upon as merely accidental, no certain relation as to its connection with a particular geological age, being presumed. Subsequent

* C. J. Karsten, Salinenkunde, vol. i, p. 220. Berlin, 1847.

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investigations gave more importance to the presence or absence of this compound; and its presence has since been recognized as especially characteristic of the salt deposits of ante-tertiary date. Consequently these have been considered as a product of the constant admixture of the oceanic waters of preceding geological periods; while on the other hand its absence in our present ocean and in most salt deposits of a more recent date, is an established fact. Although the results obtained by numerous investigations are such as scarcely to admit of a doubt, that changes in regard to the chemical composition of the oceanic waters have taken place in the course of time, and are still in progress, we must acknowledge, that our ideas concerning the main features of the primitive or silurian oceans are still vague, and especially so upon this one point.

As mineral waters and brines issuing from Silurian rocks are at present the only sources from which we can draw information, our conclusions must partake of a more or less arbitrary character; for both these saline solutions may be due to a percolation of fresh water through Silurian rocks impregnated with the *entire* saline matter of the concentrated or evaporated marine waters of a preceding, a contemporary, or a succeeding geological period; or, they may be due to a re-solution of portions of such deposits, or to a mere oozing out of their mother-liquors in in a more or less diluted condition. The difficulties in establishing even approximately their original composition are increased when we contemplate the possible changes which the original saline mass may have suffered in the course of time* in consequence of mechanical and chemical influences and subsequent alterations of its partial solutions in passing to the surface. Yet as long as the discovery of a well preserved marine evaporation of undeniable Silurian origin does not furnish us with a fitter material to study, we have to make the best of the means at hand; for it cannot be denied, that much interesting and useful information bearing upon general principles in chemistry and geology has been and may hereafter be drawn from the study of the saline solutions, mineral waters and brines of decided Silurian origin, i. e., issuing from Silurian rocks. The Silurian rocks of the State of New York abound with saline springs and mineral waters of various kinds;† the same fact is known in Canada. T. S. Hunt has recently illustrated‡ by analytical statements, the relation which various kinds of mineral waters, mainly from Canada, bear toward each other; his arguments tend to prove, that the various classes of Canadian waters

* An examination of the rock salt deposit at Stassfurt, Germany, shows that the whole deposit suffered at a later date from influences which, among other results, caused the formation of Tachhydrite (=CaCl+2MgCl+12HO—Rammelsberg, etc.) —F. Bischof, Steinsalzwerke bei Stassfurt. Berlin, 1864, pp. 33–34.

† See Geology of State of New York, etc.

‡ This Journal, March, July, September, 1865.

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referred to in his essay can be considered as originating from one and the same primal source; and that they have changed in consequence of the peculiar kind and condition of the rocks with which they came in contact. The changes themselves appear to be more considerable where disturbances and molecular changes within the sedimentary rocks have favored disintegration.

The main reaction upon these saline waters is ascribed to alkaline solutions, resulting from decaying feldspathic rocks, soluble silicates and particularly carbonate of soda.* The differences which are observable in these waters in regard to the relative proportions of chlorid of sodium and the admixtures of alkaline earths whilst passing through the various stages of alteration, are explained by the fact, that the alkaline earths, lime and magnesia, are gradually rendered less soluble and thus partly eliminated as sediments in consequence of the change from chlorids and sulphates into carbonates and silicates, and that finally the eliminated chlorid of calcium, and magnesium, reappear as an increased amount of chlorid of sodium.

In a previous publication† I described a series of experiments which had been instituted for the purpose of supporting the view entertained by myself in regard to the chemical composition of a certain class of mineral waters of Onondaga Co., N. Y., and their relations to the brines of Syracuse in particular. In the course of that discussion I stated that a sufficient amount of carbonate of magnesia added to these brines, displaced quite readily the chlorid of calcium by forming chlorid of magnesium and carbonate of lime, and produced finally, at the expense of the sulphate of lime, if exceeding the chlorid of calcium in chemical equivalents, sulphate of soda, chlorid of magnesium, and carbonate of lime, provided an excess of free carbonic acid was secured during the whole reaction. The mode of alteration in the chemical composition of these brines, then merely indicated, appeared to me of sufficient interest to merit some more detailed illustration, particularly for the following reasons.

The brines of Onondaga issue from rocks of the Upper Silurian age; they indicate with great probability, by their composition, concentration, and copiousness, a close connection with quite an extensive salt deposit‡ of that age, and thus may represent, to a certain extent at least, the constitution of a quite prim-

* Soluble silicates of potassa and soda, and carbonate of soda, etc., have been for years applied to accomplish similar alterations, for technical purposes.

† Contribution to the Chemistry of the Mineral Springs of Onondaga, N. Y. —Syracuse, Feb., 1866; and also this Journal, September and November, 1866.

‡ The brine furnished for the manufacture of salt since 1797 may be set down as being equal to at least two hundred millions of bushels of salt (each 56 lbs.); nearly ⅔ may be counted for the last ten years; counting one cubic foot of solid salt equal to 140–142 lbs., about 15·5 cub. ft. will make one heavy ton (2240 lbs.); the amount of salt therefore removed since 1797 from that locality is equal to five millions of heavy tons, or seventy-five to eighty millions cub. ft. of solid salt.

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itive salt formation; consequently any investigation of their changes promised some chance of obtaining information concerning the nature and extent of the various causes assigned for the existing differences in the chemical composition of the oceanic waters and the saline deposits of earlier and recent date.

Taking this view I intend to treat, in the following pages, of some changes, which the brines in question and those of similar composition* may suffer in regard to their chemical composition, adopting the following order:

First, changes in consequence of concentration; second, changes due to an access of carbonate of magnesia in presence of free carbonic acid, concluding with some generalizations.

I. *Changes in composition due to concentration.*—The brines in question contain from 16 to 17 per cent of saline matter; they are clear, colorless, and highly charged with carbonic acid gas when they issue from the wells; exposed to air they soon become turbid, deposit a small amount of hydrated peroxyd of iron and after some time become clear again.

A separation of gypsum and, under certain conditions,† of carbonate of lime also takes place subsequently, first as an incrustation on the sides of the vessels, afterward, particularly toward the point of saturation, as a film of crystals, partly swimming upon the surface, partly floating about the bottom. No further visible changes, aside from the increasing separation of chlorid of sodium and gypsum, are noticeable for some time until the evaporation practically ceases.‡

The following analytical statements may convey some idea of the changes within the liquid during the process of concentration at ordinary temperatures.

	I.	II.	III.	IV.	V.
Sulphate of lime,	0·5772	0·4110	0·1146	0·0304	0·0264
Chlorid of calcium,	0·1533	0·2487	2·6959	7·3420	10·4690
Chlorid of magnesium,	0·1444	0·2343	2·7513	6·2926	10·5020
Chlorid of potassium,	0·0119	0·0194	0·8177	undet.	3·3769
Bromid of magnesium,	0·0024	0·0039	undet.	undet.	0·4485
Iodine, etc.,	traces	undet.	"	"	undet.
Carbonic acid,	undet.	"	"	"	"
Chlorid of sodium,	15·5317	25·7339	20·1006	10·0901	8·7441
Carb. of protox. of iron,	0·0044	undet.	undet.	undet.	undet.
Water,	83·5	73·3	73·4	....	....

The analytical examinations being designed merely to answer certain questions, were not, as a general rule, carried out farther than is directly stated.

* Karsten's second class of brines. The principles on which Karsten has based his classification are still acceptable for practical purposes; yet chemists might prefer at the present day to reverse simply his orders, for there seems, according to our present information, but little doubt that the brines of his first class are more or less derivatives of his second class, i. e., of those containing chlorid of calcium.

† This Journal, II, xlii, 372, Nov. 1866.

‡ Farther details in regard to these questions are given in my paper "On the manufacture of Solar Salt, etc." Syracuse, Dec. 1863, page 17.

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Analysis No. I is from the brine of a particular well at Syracuse, and represents that brine, as far as figures have been given, in its original composition; analysis No. II is obtained from that same brine after being brought simply to the point of saturation; analyses Nos. III, IV, V, are from mixtures of brines from different wells; they were collected at different stages of concentration and the subsequent separation of the crystallized chlorid of sodium, etc. The discrepancies in regard to the varying relative proportions of the chlorids of calcium and magnesium observable in the foregoing statements are due to some slight differences in the composition of the original material subjected to evaporation. I stated on a former occasion that within a certain limit these brines differ somewhat in regard to the relative proportions of the deliquescent chlorids; these differences, although most trifling from a practical point of view so far as the brines are concerned, appear quite conspicuous, when the mother-liquors (or bitterns) are compared. A liquid of the composition of No. V has practically ceased to evaporate in our section of the country; its volume is constantly fluctuating, being influenced by the season and the condition of the atmosphere.

A glance over the various analyses suffices to show, that a large amount of sulphate of lime ($\frac{1}{4}$) is rendered insoluble before the crystallization of chlorid of sodium begins, and that the deliquescent chlorids of calcium and magnesium in Nos. III, IV, V, have materially interfered with the solubility of both chlorid of sodium and sulphate of lime. A closer examination into the relative proportions of the principal components of the liquids Nos. I and V proves that at least more than one thousand parts of chlorid of sodium and more than forty parts of the sulphate of lime must have been separated from solution No. I before a residual liquid of the composition of No. V could be obtained. Testing the separated saline mass on the other hand, we notice the following facts, which are a true type of the recognized condition in natural saline deposits; the chlorid of sodium which crystallizes out of the solution No. I during a continued evaporation, being impregnated with the remaining mother-liquor, contains always more or less of the chlorids of calcium and magnesium, besides the whole amount of the sulphate of lime separated. The relative proportion in which these two chlorids may be retained within the separated chlorid of sodium, corresponds closely with that of the original brine, while the entire amount of both present in the crystalline mass, is governed by particular circumstances; slow evaporation and steadiness of temperature, for instance, by favoring well developed individual crystals, react most decidedly toward their exclusion. The sulphate of lime, on the other hand, varies in quantity in the different layers of crystals

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of chlorid of sodium, throughout its whole mass; in cases where the evaporation has been started with a brine like No. I above, it forms the basis of the whole saline deposit and gradually decreases in quantity toward the close of evaporation, or within the upper layers.

I deem it of some interest, and therefore call attention here to the great resemblance in chemical composition of the saline liquid, No. V above, and some of the mineral waters of Canada, as shown by T. S. Hunt's analyses, particularly No. 4.*

It will be noticed that the results of evaporation previously stated will serve as a strong argument in favor of the view advanced concerning the probable origin of that whole class of mineral waters, namely, that they originate from mother-liquors or bitterns of the saline residue of marine evaporations of the Silurian age. The essential difference in the instances alluded to is apparently merely one of concentration. The Upper Silurian rocks in our vicinity are similarly impregnated with these assumed mother-liquors (or re-solutions of the upper layers of salt deposits) as the Lower Silurian rocks around the north and northwestern shores of Lake Ontario are represented to be.† The similarity in composition between the saline waters from both localities‡ manifests itself even in the peculiar variations in the relative proportions of the most characteristic compounds, particularly the deliquescent chlorids of calcium and magnesium, as may be seen from the following analyses of waters taken from the vicinity of Syracuse.

One hundred parts contain—

	A.	B.	C.
Sulphate of lime, . . .	0·0058	0·0794	1·7000
Chlorid of calcium, . .	4·8200	6·1143	8·4800
Chlorid of magnesium, . .	0·9281	1·7844	0·7830
Chlorid of potassium, . .	undet.	undet.	0·3530
Chlorid of sodium, . .	15·2288	8·7263	9·2430
Carbonate of iron, etc., . .	traces	traces	undet.§
Water, ...	79·0	83·3	979·441
	100·0000	100·0000	1000·0000

* This water is from the vicinity of the bay of Quinte; 1000 parts contain of

Chlorid of sodium,	17·4000
" potassium,	undet.
" calcium,	9·2050
" magnesium,	9·4843
Bromid of sodium,	undet.
Sulphate of lime,	" etc.

Table I, waters of first class; this Journal, II, xl, 44, July, 1865.

† T. S. Hunt, (loc. cit.).

‡ The question in regard to their real source so far as particular geological epochs are concerned, is, we presume, in many cases still open to discussion.

§ The presence of this large amount of sulphate of lime, and of carbonates is apparently due to an admixture of drainage waters from surface percolation, which pass through gypseous shale and diluvial drift.

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If such relations exist in regard to the natural saline bitterns of both localities, as the history of the liquid No. V suggests, we may be entitled to assume, considering the area of actual observation the existence of extensive salt deposits within the Silurian basin. To advance here opinions in regard to their particular origin in either case, would be of little value, so long as careful local examinations are still wanting; since marine evaporations or salt deposits may occur independently of each other, between the successive strata within the same basin;* and irregularities and ruptures in the level of the rocks, caused by physical and chemical reactions from within and without, are quite frequently observed in the vicinity of salt deposits. Moreover, inferences drawn merely from the level of the rocks and the depths of the borings without a previous careful tubing of the latter are not less unreliable, than the conclusions adduced from the differences of temperature between the mean temperature of the locality in question and that of the saline waters issuing from the springs or wells; for the common rule of drainage may be changed by fissures, etc., and causes which produce alterations of temperature in consequence of chemical reactions are never wanting in circumstances like those under consideration. The decided differences in regard to the relative proportion of the saline waters, No. I, p. 80, and A and B, p. 82, which occur within quite a limited territory will in all probability find a less acceptable explanation, in the opinion of many, by supposing a difference in the chemical character of intercepting strata, than by assuming either entirely different sources or independent local secondary influences, similar to those for instance at Stassfurt, aided by irregularities in the level of the rocks of the same geological period,† for the brines of Syracuse are characterized by their small percentage of deliquescent chlorids of nearly *corresponding* quantity and their proportion of sulphate of lime, marks of particular significance considering the surrounding conditions.

II. *Changes in composition due to the reaction of carbonate of magnesia upon chlorid of calcium and sulphate of lime in the presence of carbonic acid gas.*—On a previous occasion I described the mode of action and the conditions under which carbonate of magnesia would act upon chlorid of calcium and sulphate of lime, both in the presence and in the absence of chlorid of sodium; only the first case belongs to the present discussion. It remains here merely to illustrate more in detail such changes as

* Two independent rock salt deposits, for instance, have been found in the Thuringian basin; one in the Permian rocks (Zechstein), the other in the Triassic rocks (Muschelkalk). (F. Bischof, Steinsalz werke bei Stassfurt. Berlin, 1864, p. 5.)

† At Stassfurt, a layer of magnesian compounds several hundred feet in thickness occurs above the rock salt, while at Schonbeck (belonging to the same deposit) this layer is wanting. (F. Bischof.)

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have been before indicated. Our brines contain both chlorid of calcium and sulphate of lime, and are highly charged with free carbonic acid; they are thus liable to undergo alterations in both the directions mentioned.

The circumstances under which these two reactions take place leave it somewhat doubtful to which particular reaction the removal of the chlorid of calcium may be ascribed, whether to a mere substitution of the calcium of the chlorid of calcium by magnesium, or indirectly to the decomposition of the sulphate of lime into sulphate of soda, carbonate of lime and chlorid of magnesium; and the subsequent reaction of the sulphate of soda thus formed, upon the chlorid of calcium, reproducing thereby again sulphate of lime and chlorid of sodium, previously decomposed. Whatever the order or the extent of either of these two distinct and available modes of changing the composition of the brine may have been in this instance, a corresponding amount of chlorid of magnesium and of carbonate of lime are in either case the final products; and as carbonate of lime rapidly separates (settling), in the case of more saturated solutions, an addition of chlorid of magnesium* equivalent to the amount of chlorid of calcium removed, remains practically the only material acquisition of the brine. Quite different are the final results, so soon as the accessible carbonate of magnesia begins to exceed the chemical equivalent of the chlorid of calcium; for by the aid of free carbonic acid† the sulphate of lime will be decomposed and thus on account of the presence of chlorid of sodium, every additional amount of the carbonate of magnesia will produce a corresponding amount of sulphate of soda, chlorid of magnesium and carbonate of lime, which compounds remain intact; these changes may thus continue until all the sulphate of lime has been decomposed. The amount of sulphate of soda, etc., liable to be produced by the foregoing reaction, depends apparently entirely upon the supply of both, i. e., carbonate of magnesia and sulphate of lime.

To render these changes more striking I will illustrate them by numerical statements:

* Attention has been called to the fact as being quite remarkable, that no brines containing chlorid of calcium without containing also chlorid of magnesium have been noticed; the reverse occurs as is well known quite frequently. Brines from the States east of the Mississippi containing no chlorid of calcium have not thus far come under my observation, while such brines seem to occur quite frequently in the States west of that river, as examinations of brines and salt from Nebraska, Kansas and Arkansas, etc., have proved to me; they also contain frequently considerable quantities of sulphate of soda, etc.

* The amount of carbonic acid noticeable in mineral waters when issuing from springs, or forced out from wells, gives rarely a correct idea of the amount at work, for their passage upward over rough surfaces, and their exposure to higher temperatures, etc., cause its partial liberation by escape through the soil, etc.

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	A.	B.	C.	D.
Sulphate of lime, . .	0·5772	0·5772	0·2885	....
" of soda, . .	....	....	0·2900	0·5912
" of potassa, .	....	....	0·0139	0·0139
Chlorid of calcium, .	0·1533	....	....	....
" of magnesium, .	0·1444	0·2756	0·4772	0·6786
" of potassium, .	0·0119	0·0119	....	....
Bromid of magnesium, .	0·0024	0·0024	0·0024	0·0024
Chlorid of sodium, . .	15·5317	15·5317	15.3028	15·0445
Water, ...	83·57	83·57	83·57	83·57
Carbonate of lime, . .	....	0·1381	0·3502	0·5625

A represents the brine with its original composition; B represents the same brine subjected to the action of but 0·1160 carbonate of magnesia dissolved in water containing carbonic acid gas; this amount of carbonate of magnesia is equivalent to the chlorid of calcium present; C represents the same brine after the reaction of 0·2943 carbonate of magnesia, causing besides the removal of chlorid of calcium also that of one half of the gypsum present; it changes chlorid of potassium into sulphate of potassa and leaves besides a corresponding excess of sulphate of soda. D represents the brine after the entire decomposition of the chlorid of calcium and the sulphate of lime; the latter is represented by sulphate of soda in solution, formed of course partly at the expense of the chlorid of sodium; 0·4725 neutral carbonate of magnesia, aided by carbonic acid gas, are required to cause such complete changes. The whole amount of lime as chlorid and sulphate in the original brine is changed into carbonate.

The carbonate of lime formed during each stage of progress has been noted separately; the largest proportion, in instances like those presented above, would settle soon after its formation, since the degree of its solubility in this case depends upon the concentration of the saline liquid, the temperature and the time of its formation, leaving the particular influence of the carbonic acid gas as a means of solution out of consideration.

Viewing these four statements from Karsten's standpoint we notice that while A belongs undoubtedly to his second class of brines, B, C and D, must be counted to those of the first class. Accepting on the other hand, the fact that such changes are going on in saline solutions in our Silurian rocks, we must concede that the saline matter of the Silurian ocean may even change within the Silurian rocks to such a degree as to resemble those of the present ocean; for, whatever essential compounds of the latter are not mentioned in the above statements, we must acknowledge can be constructed from their components present, making allowances for influences of temperature, and concentration, and for the peculiar view taken in regard to chemical

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affinity under both of these circumstances; the difference in the *relative proportions* of the *various compounds* depends on entirely different causes.

The particular conditions required to render such a change of the brine possible, are, it can scarcely be denied, abundantly supplied, particularly in consequence of the extensive exposure of our Silurian rocks. Chlorid of sodium has been and is still performing a most important part in the disintegration of a large number of rocks, by chemical and particularly by mechanical forces in consequence of its hygroscopic quality.

Chlorid of sodium and sulphate of lime are almost everywhere associated; they occur not only as more or less well defined deposits of varying extent, but they must originally have pervaded every sedimentary rock from the lowest Silurian to the latest marine formation. Subsequently they have found access to many formations of a later date and different origin by the ascent of percolating waters. Most of these rocks contain, more or less abundantly, compounds of magnesia, particularly carbonates,* and have thus uninterruptedly yielded quantities of that substance to solutions, wherever such powerful disintegrating agencies as change of temperature, access of moisture and free carbonic acid have been at work; the destruction of these rocks is a mere matter of time. Many sedimentary rocks may have been exposed to these influences temporarily, perhaps in a less indurated state, and consequently have presented conditions most favorable for transformation and subsequent extraction; circumstances which may sometimes account for the total or partial abstraction of sulphate of lime from a number of sedimentary rocks of marine origin.†

Relying here, more on the duration than on the intensity of the action, I believe that the final results of reactions like those considered in the foregoing discussion, must *in common with other causes*, have exerted an important bearing on the composition of the marine waters, during the development of our present surface-configuration; and they may in particular instances have assumed proportions sufficiently extensive to account even for more localized accumulations of sulphate of soda, in connection with

* Researches of Ebelman, confirmed by T. S. Hunt, have proved that magnesia and lime are first abstracted, by means of carbonic acid, from even basaltic and similar rocks and that in the case of labradorite, the removal of these two alkaline earths was even more complete than that of the alkalies, (this Journal, II, xxxix, 181, March, 1865); a series of analyses of waters from along the N. Y. Central railroad by Dr. C. F. Chandler (New York, 1865), as well as some of my own analyses furnish a direct proof of the fact, that the carbonate of magnesia enters in an unusual proportion into the composition of a large number of our spring waters.

† Mineral waters issuing from rocks in the city of Oswego (gray sandstone) along the Oswego river contain large percentages of chlorid of sodium, besides the chlorids of magnesium and calcium; they are free from sulphate of lime. Analysis gives, in 1000 parts, NaCl 5·622, MgCl 0·140, CaCl 0·3152, etc.

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chlorid of sodium as well as with other saline compounds. The whole reaction of carbonate of magnesia, in the presence of carbonic acid gas, upon brines like ours, resembles somewhat, so far as some of the final results are concerned, that of carbonate of soda provided the latter does not exceed in chemical equivalents the chlorid of calcium and sulphate of lime present, sulphate of soda, and carbonate of lime being formed in both instances; they differ only in one essential point; in case of the addition of carbonate of soda the chlorid of calcium is simply eliminated (only traces of carbonate of magnesia being produced) and its place supplied by a corresponding amount of chlorid of sodium, while in the case of the addition of carbonate of magnesia the chlorid of calcium is replaced by a corresponding quantity of chlorid of magnesium. The following statement demonstrates the changes due to the addition of an amount of carbonate of magnesia or of carbonate of soda chemically equal to the amount of chlorid of calcium present, since, as soon as that point is passed both carbonates produce sulphates of soda, as long as sulphate of lime remains in excess.

	1.	2.	3.	4.
Sulphate of lime, . .	0·5772	0·5772	0·5772	0·7652
Chlorid of calcium, . .	0·1533	....	....	....
" magnesium, .	0·1444	0·2756	0·1444	0·1444
" potassium, . .	0·0119	0·0119	0·0119	0·0119
Bromid of magnesium, .	0·0024	0·0024	0·0024	0·0024
Chlorid of sodium, . .	15·5317	15·5317	15·6933	15·6933
Water, ...	83·57	83·57	83·40	84·10
Carbonate of lime, . .	....	0·1381	0·1381	....

1 represents the original brine; 2 represents this brine treated with the necessary amount of carbonate of magnesia; 3 represents this brine (1) treated with a corresponding amount of carbonate of soda; 4 represents the original brine simply treated with an additional amount of sulphate of soda. We can scarcely imagine the variety of brines and mineral waters which may result in the course of time from this or similar brines, under different geological conditions, particularly if we consider the consequences, which must result from a mere difference in concentration before or after such changes as we have discussed in these pages have been fully or partly accomplished.

Slim indeed are the chances of learning anything more definite about the original composition of the saline mass of the oceanic waters of the Silurian age from our mineral waters and brines; since the extensive exposure of our Silurian rocks renders them subject to important changes by disintegration, and causes them to react decidedly upon percolating saline solutions.

Syracuse, March 14, 1867.

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ART. XI.—*Notice of a new Genus of fossil Sponges from the Lower Silurian;* by Prof. O. C. MARSH, of Yale College.

WITHIN the last few years several specimens of a remarkable fossil have been found in limestone of lower Silurian age in Franklin county, Kentucky. Although generally recognized as *Amorphozoa* by paleontologists who have seen them, and evidently new to science, no description of them appears to have been published hitherto, except a brief notice by Prof. D. D. Owen, who proposed for them the name of *Scyphia digitata.**

The Cabinet of Yale College contains a very perfect specimen of this fossil, recently obtained from Prof. Hovey of Wabash College; and the writer had previously an opportunity of examining, in the collection of Mr. Sydney S. Lyon, of Jeffersonville, Indiana, a large and fine specimen, the original from which casts have since been supplied to the Yale and other museums, by Prof. Ward of Rochester.

In general appearance, and nearly all important characters, these two specimens are very similar. The form is that of a short vase, or cup, with a row of arms extending outward and downward from the lateral surface. These arms are hollow, and open directly into the main or central cavity, which is apparently larger than in any other known sponge, recent or fossil.

The specimen in the Yale collection is about six inches in diameter, and three in height. It has nine arms of nearly equal size and length, all with openings at their extremities. The base has a small protuberance near the center, but no other indication of attachment. The other specimen has eleven arms, and is nearly eleven inches in diameter, by three and a half in height. Both specimens are externally silicified. The main orifice, or mouth, is oval in form, and in the smaller specimen is situated at the end of a short neck, about one and one-half inches above the bases of the arms.

As these specimens are without doubt generically distinct from any yet described, the name *Brachiospongia* is proposed for the genus they represent; and, since there is apparently more than one species included under the name *digitata*, the trivial designation of *Rœmerana* may be added, in honor of Prof. Ferdinand Rœmer, of Breslau University, whose investigations have thrown so much light upon paleozoic sponges. The specimen in the Yale Cabinet may be regarded as typical of this species. Should the form represented by the large specimen already noticed prove a distinct species, this may appropriately be named *Brachiospongia Lyonii*, from Mr. S. S. Lyon, the discoverer of these interesting fossils. A full description of these specimens, with illustrations, will appear in an early number of this Journal.

New Haven, Ct., May 25th, 1867.

* Second Report on the Geology of Ky., p. 111.

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ART. XII.—*Crystallogenic and Crystallographic Contributions;* by JAMES D. DANA. No. IV,* *On a connection between Crystalline form and Chemical constitution, with some inferences therefrom.*

AMONG oxyds, the protoxyds, like the metallic elements, are characteristically *isometric*† in crystallization. The sesquioxyds are as characteristically *hexagonal*, this being the form of the sesquioxyds of iron, aluminum, and chromium. The deutoxyds are typically *tetragonal*, as seen in the deutoxyd of tin (tin ore) and of titanium (rutile and anatase). There are other forms among protoxyds, sesquioxyds and deutoxyds; for example, ZnO is hexagonal; TiO^2 in brookite, and MnO^2 in pyrolusite are orthorhombic; but these cases, as the following observations make apparent, may be regarded as a consequence of polymerism —a principle that has been recognized by others as underlying dimorphism.

Regarding the atom of oxygen as double in its fundamental

* The preceding papers in this series by the writer are not numbered. They are: I, On the Formation of Compound or Twin crystals, vol. xxx, 275, 296, 1836; II, On certain laws of Cohesive Attraction (as illustrated by crystals); II, iv, 364, v, 100, 1847, 1848; III, On the Homœomorphism of mineral species of the trimetric [and other] systems, II, xviii, 35, 131, 1854, with the antecedent papers in xvii, 85, 210, 430.

† I propose to employ in the forthcoming edition of my Mineralogy the terms *Isometric, Tetragonal* (having a square base), and *Orthorhombic* (erect on a rhombic base), in place respectively of *Monometric, Dimetric*, and *Trimetric* *Monometric* describes a line better than a cube; the hexagonal prism is as much *dimetric* as the square prism; and the oblique prisms are as truly *trimetric* as the right rhombic. It is very desirable that the technical terms of science should be uniform over the world, as far as possible, and that authors should be willing to yield their own usage for the sake of uniformity. The terms adopted appear to be the best that have been proposed, and have already extensive use in Europe. *Isómetric* is Hausmann's term; *tetragonal* and *hexagonal*, with *rhombic*, are employed by Naumann. Mohs's terms *pyramidal* for the tetragonal system, and *prismatic* for the orthorhombic, are exceedingly bad, as there are pyramids among isometric, orthorhombic and hexagonal forms, as well as the tetragonal; and prisms in all the systems excepting the isometric.

There is additional reason, for our proposed change, in the natural relations of the systems of crystallization. For the similarity in the names *monometric, dimetric, trimetric* (the latter two the *monodimetrischen* and *trimetrischen* of Hausmann) implies a fundamental relation in the forms; while the true classification is as follows: (1) *Isometric*, including the isometric system, peculiar in the absence of double refraction or polarization; (2) *Isodiametric* (from ἴσος, *equal*, and *diameter*), including the tetragonal and hexagonal forms (alike named from the shape of the base), characterized by equal transverse axes or diameters, and uniaxial polarization; and (3) *Anisometric* (from ἄνισος, *unequal*, etc.), including the remaining systems, and distinct in having the axes or diameters all unequal, and biaxial polarization.

Monoclinic, Diclinic, Triclinic (from Naumann) I would retain, as they express admirably the relations of the systems. *Clinorhombic* is often used for the monoclinic system, and is well enough. But *clinorhomboidal* for the triclinic would not be desirable, as the French commonly use the word *rhomboidal* where others use rhombic; and the *diclinic* could have no corresponding name, unless it be *clinorectangular*, which would be very objectionable.

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nature, the number of atoms of oxygen (or the negative element) in the protoxyds is 2; in the sesquioxyds 6, or a multiple of 3; in the deutoxyds 4.

It appears from a survey of all hexagonal and tetragonal compounds to be a general fact, that the number of atoms of the negative element is 3, or a multiple of 3, in the former; and 2, 4, or a multiple of 4, in the latter; and that, consequently, the hexagonal and tetragonal systems are based on these numbers, respectively, their symmetry being a consequence of it.

1. *Tetragonal species, and the number* 4.—Among *unisilicates*—the silicates which have the ratio 1 : 1 between the oxygen of the bases and silica (SiO^2), and the number of atoms of oxygen 4, or its multiple—tetragonal species are common; while none occur among the *bisilicates*, in which the ratio is 1 : 2, and the number of atoms of oxygen is 3, or its multiple. There are none also among the anhydrous carbonates, which likewise have the oxygen ratio 1 : 2. But among these bisilicates and carbonates there are examples of *hexagonal* species. The compounds $\dot{C}a\dddot{W}$ (scheelite), $\dot{P}b\dddot{W}$ (scheeletine), $\dot{P}b\dddot{M}o$ (wulfenite), $\dot{Y}^3\dddot{P}$ (xenotime) are tetragonal, the last having 8 of oxygen (or 16 if doubled) and the others 4. Matlockite ($PbCl+PbO$) is tetragonal, while $PbI+2PbO$ is hexagonal, and $PbCl+2PbO$ is orthorhombic. Cerasine ($PbCl+\dot{P}b\dot{C}$) is tetragonal; and the number of atoms of the negative elements, O, Cl, is 4. Hausmannite is tetragonal, and with the usual formula $\dot{M}n\dddot{M}n$ has 4O. Yet the formula is better written $\dot{M}n^2\dddot{M}n$, for this corresponds with its close relation in form to the RO^2 or deutoxyd group, while $\dot{M}n\dddot{M}n$ is a formula of the isometric spinel group. Similarly, the tetragonal species chalcopyrite has the formula $2(\dot{C}u, Fe)S+FeS^2$. Braunite, taking the most recent formula for it, that of Rammelsberg, $(Mn, Si)^2O^3$, is apparently an exception. Its composition, as Rammelsberg shows, corresponds to $3\dddot{M}n+\dot{M}n+\dot{S}i$, and this formula has 12O, which is a multiple of 3, and satisfies the principle under illustration. But the true arrangement of the constituents makes it not a sesquioxyd, as above, but a *deutoxyd* like hausmannite, which it approaches in its tetragonal form; for the formula may be $2\dddot{M}n^2\dddot{M}n+\dot{M}n\dot{S}i$, which is equivalent to 2 of hausmannite and 1 of a silicate analogous to the tetragonal species zircon ($\dot{Z}r\dot{S}i$).* The deutoxyd of manganese, MnO^2 (pyrolusite), is orthorhombic, and approximately isomorphous with orthorhombic TiO^2 (brookite), the former having for the angles of

* Hausmannite approaches more closely the anatase form of TiO^2 than the rutile form, the angle between *O* and the plane made 1-*i* in anatase being 119° 22′, and *O* : 1 (which might as well be 1-*i*) in hausmannite being 121° 3′. Braunite is much nearer cassiterite, rutile, and zircon, the corresponding angles for *O* on a pyramidal plane in these four species being, respectively, 135° 26′, 136° 26′, 137° 49′, 137° 50′. Thus the anatase and rutile form of TiO^2 are severally represented by hausmannite and braunite.

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the prism *I*, and the domes 1-$\bar{i}$, 1-$\breve{i}$, respectively, 93° 40′, 104° 22′, 107° 54′; and the latter for the corresponding angles 93° 16′, 96° 46′, 99° 50′. MnO^2 in the tetragonal state is unknown except when it is in combination with 2MnO, as in hausmannite. The protoxyd of manganese, MnO, it may be remarked, is isometric, like MgO, it having been obtained artificially in octahedrons and cubo-octahedrons by Deville (C. R., liii).

Among artificial compounds, there are the following tetragonal species all conforming to the principle stated:

$KF + HF$; $\dot{B}e\bar{S} + 4aq$; $\dot{N}i\bar{S} + 7aq$; $\dot{N}i\bar{S} + 6aq$; $\dot{N}i\bar{S}e + 7aq$; $\dot{Z}n\bar{S}e + 7aq$; $(\dot{K},\dot{H})^3\bar{P}$; $(\dot{A}m,\dot{H})^3\bar{P}$; $(\dot{K},\dot{H})^3\bar{A}s$; $(\dot{A}m,\dot{H})^3\bar{A}s$; $\dot{C}a\bar{C} + 2aq$; $(\dot{A}m+\dot{H})\bar{B}^2 + 3aq$; NaO, IO^7; $KCl + CuCl + 2aq$; $AmCl + CuCl + 2aq$; $\dot{A}g\bar{S} + 2NH^3$, $\dot{A}g\bar{C}r + 2NH^3$, $2\dot{K}\bar{A}c$ (acetic acid) $+ \dot{C}u\bar{C} + 12aq$; $\dot{C}a\bar{A}c + \dot{C}u\bar{A}c + 8aq$, $\dot{K}\bar{A}c + 2\bar{C}\bar{A}c + 2aq$, $\dot{A}g\bar{A}c + 2\bar{C}\bar{A}c + 2aq$; $(\frac{1}{3}\dot{C}a + \frac{2}{3}\dot{H})^3\bar{T}$ (tartaric acid, containing 5O) $+ \bar{S}b\bar{T} + 7aq$.

Omitting a few complex organic compounds, these are all the tetragonal species in the two volumes of Rammelsberg's Crystallographic Chemistry excepting $\dot{A}g\bar{C}l$, Hg^2Cl. Other examples might be mentioned, but the above are fully sufficient.

The correspondence with the law for tetragonal species is so general that we may reasonably believe that the apparent exceptions, where the composition and crystallization are correctly given, may be brought into conformity to it by an application of one or the other of the following principles.

a. The principle of polymerism.—Hg^2Cl is Hg^2Cl^2 in the new system of chemistry; and if the whole is doubled, it becomes Hg^4Cl^4, which is probably the true formula of this species in the tetragonal state, the only crystalline state yet known.

b. Part of the ingredients may be only accessory, or subordinate to a dominant part which determines the crystallization.—Water is commonly admitted to be present in this way in most of the compounds in which it occurs; although essential to the species, it is subordinate, crystallogenically at least, to the rest. Water is now believed to be not the only substance that may play the part of indifferentism in compounds, and many formulas have of late been written by chemists admitting this. Apophyllite is a tetragonal species consisting of $\dot{R} + 2\dot{S}i + 2\dot{H}$. Making the water basic, there is still no conformity to the type of either the unisilicates or bisilicates, the oxygen ratio for the bases and silica being 3 : 4. If half the water be regarded as basic, and the formula be written $(\dot{R},\dot{H})^2\dot{S}i + \dot{H}\dot{S}i$, it is made to consist of a dominant part which is a unisilicate analogous to the tetragonal species meionite, mellilite, etc., and a bisilicate which is a kind of opal or waterglass, well known to be a "colloid," or uncrystallizable, and which therefore might well have no effect toward modifying the crystallization as determined by the other part.

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2. *Hexagonal species, and the number* 3.—Hexagonal species have been stated to occur among the sesquioxyds (as Fe^2O^3, Al^2O^3, Cr^2O^3); the bisilicates (as in beryl, eudialyte, dioptase, pyrosmalite, chabazite, gmelinite); and the carbonates (in calcite, and the allied species); in which compounds the number of atoms of oxygen is 3, or a multiple of 3. Other examples are:

Pyrargyrite and proustite, $3AgS+(Sb, As)^2S^3$, in which the number of atoms of sulphur is 6; gibbsite $\dddot{Al}\dddot{H}^3$; alunite $\dot{K}\dddot{S}+3\dddot{Al}\dddot{S}+6aq$; apatite $3\dddot{Ca}^3\dddot{P}+CaCl$; coquimbite $\dddot{Fe}\dddot{S}^3+9aq$; Al^2Cl^3+12aq; $\dot{Mg}\dddot{S}+6aq$; $\dddot{Al}\dddot{S}^3+27aq$; $SrOS^2O^5+4aq$, and the corresponding salt of lime, and of lead; $\dot{K}\dddot{N}$; $\dot{N}a\dddot{N}$; $(\dddot{Ca}+\dddot{H}^2)\dddot{C}$; $AgO, ClO^7+4\dddot{H}$; $3NaCl+IrCl^3+24aq$; $KCl+2MgCl+12aq$; $MgCl+PtCl^2+6aq$.

The exceptions to the principle are to be accounted for in the same manner as those under the tetragonal system. Along side of the hexagonal sesquioxyds, Fe^2O^3, Al^2O^3, Cr^2O^3, there is the hexagonal protoxyd ZnO, similar in angle. Applying the principle of polymerism and writing the formula Zn^3O^3, it then has, like the sesquioxyds, 3 of O. This view of the protoxyd is abundantly illustrated and sustained among the silicates. For the constitution of the larger part of them (garnet, scapolite, epidote, etc.) is based on the mutual replacement of 1 of sesquioxyds (R^2O^3), and 3 of protoxyds (3RO); and this mutual replacement signifies isomorphism of R^2O^3 and R^3O^3. Again, graphite, or *hexagonal* carbon, has been shown to have its atomic weight nearly three times as great as that of ordinary carbon; and it is altogether probable, therefore, that in this hexagonal state carbon is C^3, in accordance with the principle in view. Hexagonally crystallized water, on the same ground, is not HO, but H^3O^3. ZnS occurs both in isometric and hexagonal forms; and while the former may be simply ZnS, the latter should be Zn^3S^3; and so for the hexagonal sulphid of Fe, Ni, Cd, we should have Fe^3S^3 (troilite, pyrrhotine); Ni^3S^3 (millerite); Cd^3S^3 (greenockite); and similarly Ni^3As^3 (copper nickel); Ni^3Sb^3 (breithauptite).

3. *Isometric system.*—The number of atoms of the negative element in isometric species appears to be either 1, 2, 3, 4, or a multiple of 3 or 4; and this diversity accords with the twofold nature of a cube; that is, (1) an equiaxial square prism, and (2) (if a diagonal be made vertical) a rhombohedron of 90°; for it has this double relation to other forms. Accordingly, isometric forms occur among protoxyds, protosulphids, protochlorids, etc.; also deutoxyds; also unisilicates; in leucite, analcime; also in—

$\dot{Mg}^2\dddot{B}^4$, or boracite; $\dddot{As}$; $\dddot{Sb}$; $\dot{N}a\ddot{Cl}_6$ $\dot{K}\ddot{Br}$; $\dot{N}a\ddot{Br}$; $\dot{N}i\ddot{Cl}+6aq$; $\dot{C}u\ddot{Cl}+6aq$; $\dot{C}o\ddot{Br}+6aq$; $AmCl+SnCl^2$; $KCy+AgCy$; $3\dot{N}a\ddot{C}+\ddot{C}r\ddot{C}^3+9aq$; the alums, which have 16O, besides 24O in the water; $\dot{N}a\dddot{Ac}+2\ddot{C}\dddot{Ac}$; $\dot{N}a\ddot{W}+\ddot{W}\ddot{W}$.

Important chemical and crystallographic conclusions flow from

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the principle which has been explained, if it is sustained, as we believe, by the facts. A few only are briefly touched upon.

1. It follows that the hexagonal state of the *elements* may be one corresponding to 3R, or 3*n*R; that while zinc in the isometric state if such exists (about which there is doubt) is Zn; in the hexagonal it may be Zn^3, the same state in which it exists in hexagonal oxyd of zinc. So also Pd, As, Sb, may represent the isometric state of the elements palladium, arsenic, antimony; but Pd^3, As^3, Sb^3, the hexagonal; and so for other cases.

2. The oxyd of copper, CuO, which may also be written CuO^2, is dimorphous, it occurring both in isometric and orthorhombic forms; and the orthorhombic form is closely isomorphous with TiO^2 in brookite—*I*: *I* and *I*: $\frac{1}{2}$ in the oxyd of copper being respectively 99° 39′ and 126° 29′, and in brookite 99° 50′ and 126° 15′. This relation to TiO^2 shows that the orthorhombic state of the cupric oxyd should have the formula CuO^2, or that of a deutoxyd, and the isometric alone that of CuO. And it indicates further that the element copper may exist theoretically, if not actually, in two corresponding polymerous states.

3. As long since illustrated by Laurent, the protoxyds RO, sesquioxyds R^2O^3, deutoxyds RO^2, and other grades of oxyds RO^3, RO^5 (and the same in corresponding chlorids, sulphids, etc.), in which 1 part of oxygen balances, in its affinity, 1, $\frac{2}{3}$, $\frac{1}{2}$, etc., parts of the basic element (as is seen on dividing by the number of atoms of oxygen so as to reduce the oxygen in all the above formulas to 1O), may be viewed as containing the basic element in as many different states as there are grades of the above compounds. For convenience these states may be designated by using the Greek letters as follows:

Formulas	RO RO	R^2O^3 $R_{\frac{2}{3}}O$	RO^2 $R_{\frac{1}{2}}O$	RO^3 $R_{\frac{1}{3}}O$	RO^5 $R_{\frac{1}{5}}O$
States of Basic element	R αR	$R_{\frac{2}{3}}$ βR	$R_{\frac{1}{2}}$ γR	$R_{\frac{1}{3}}$ δR	$R_{\frac{1}{5}}$ ϵR

or the *alpha*, *beta*, *gamma*, *delta* and *epsilon* states. It is observed that $3RO=R^3O^3$; $3(\beta RO)=R^2O^3$; $2(\gamma RO)=RO^2$; $3(\gamma RO)=\frac{3}{2}RO^2$; $3(\delta RO)=RO^3$; and so on: in other words, the *one* molecule R^2O^3 corresponds to *three* of βRO; and in $3(\beta RO)$ there are as many atoms of the basic element βR as of O.

Now, if a sesquioxyd occurs in *isometric* crystals, as supposed to be true of Fe^2O^3 (but reasonably doubted), that sesquioxyd is not Fe^2O^3, but may be $Fe_{\frac{2}{3}}O$. This is but the converse of the conclusion, stated above, that if a protoxyd occurs in *hexagonal* crystals it is not then RO, but may be R^3O^2. So in other cases: if oxyd of tin had an isometric as well as a tetragonal form, the former in the crystalline state should be $Sn_{\frac{1}{2}}O$, and only the latter

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SnO^2. A metal in the different states R, $R_{\frac{2}{3}}$, $R_{\frac{1}{2}}$, has, accordingly, the same isomorphic power; and so also, 2R, $2R_{\frac{2}{3}}$, $2R_{\frac{1}{2}}$; and 3R, $3R_{\frac{2}{3}}$, $3R_{\frac{1}{2}}$. Hence under the principle explained—

RO, $R_{\frac{2}{3}}O$, $R_{\frac{1}{2}}O$ should be alike *isometric* in crystallization.

2(RO), $2(R_{\frac{2}{3}}O)$, $2(R_{\frac{1}{2}}O)$ may be *tetragonal* " "

3(RO), $3(R_{\frac{2}{3}}O)$, $3(R_{\frac{1}{2}}O)$ may be *hexagonal* " "

Quartz, which is hexagonal silica, should, according to the above, be $3(Si_{\frac{2}{3}}O)$, or else $6(Si_{\frac{1}{2}}O)$, and not $2(Si_{\frac{1}{2}}O)=SiO^2$. SiO^2 is hence unknown in the crystalline state; and if ever obtained crystallized it will in all probability have one of the forms of TiO^2. Common uncrystallizing silica, or opal-silica, low in density, may be silica in the isometric form, or $Si_{\frac{1}{2}}O$, but with so feeble crystallizing power as never to exhibit any thing but the so-called *colloid* condition. Whether isometric silicon, crystals of which have been obtained artificially, is simply silicon in the *alpha* state, or not, cannot be at once decided; for it is probable that diamond, which is isometric carbon, is equivalent to C^4, its density, and the product of the atomic weight by the specific heat, indicating this relation to graphite.* As "graphitoidal" silicon has turned out to be only isometric silicon, we have no chance for a comparison, like that with respect to carbon.

Anatase is probably TiO^2, and rutile Ti^2O^4, the density of the latter being 4·2, of the former only 3·9. The relations of hausmannite and braunite (p. 90, note) accord with this, the latter containing *two of hausmannite*. Brookite is intermediate in density, and in the temperature of origin, and hence may be $\frac{3}{2}(TiO^2)$. It would appear, therefore, that the species of *highest polymerous state*, rutile, forms at the highest temperature.

4. The views illustrated sustain the conclusion that the different states of elements represented above are fundamentally distinct: that Fe in the *alpha* state is related to all other metals that are in the same state, including K, Na (K_2, Na_2 in the new system of chemistry), as well as Mg, Ca, etc.; that Fe, Cr, Co, in the *beta* state are of the same group of elements with aluminum in alumina: that Fe, Mn, Cu, Pb in the *gamma* state should be classed with Ti, Sn.

5. Aid is given by the principle explained toward determining in many cases what are the accessory and what the dominant ingredients in a compound, and thence what should be regarded as its true constitution.

6. Crystallogeny hereby learns that *quadratic or tetragonal symmetry in crystals depends on quadratic symmetry, or the recurrence*

* For this inference with regard to the equivalent of carbon in the diamond I am indebted to Prof. G. F. Barker, who offered it while I was explaining to him the views contained in this paper.

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of fours, in the number of atoms of the negative part of a compound; and hexagonal symmetry, in like manner, on the presence of triads or hexads of the same atoms. Moreover, on the view explained, the number of atoms of the more positive element or elements, in the simpler compounds at least, may be just equal to that of the negative. For since $3(\alpha RO)=R^3O^3$, $3(\beta RO)=R^2O^3$, and $3(\delta RO)=RO^3$, there are, in these oxyds, as many atoms of αR, βR, δR, as of O; and if the elements may exist in these divided states, they may thus make with the O the crystallogenic molecule.

The precise arrangement of the constituent atoms in a molecule subsisting in any case, and producing the characteristics and special dimensions of the crystal, yet remains to be explained. This much may be safely deduced: that the negative atoms must be grouped—and in the systems here referred to, under quadrate or hexad symmetry—at or toward one extremity of the molecule, and the positive at or toward the opposite; and that the molecule in this way derives its polarity—a characteristic abundantly manifested in the formation, the forms, and the physical natures of crystals,* though not often apparent in mechanical effects, and which is in accordance with the most fundamental of nature's laws. The different constituent elements or parts of a compound may differ in *degree* of negativity or positivity, and even the same element may be present in opposite states; such constituents would have their places accordingly, though with subordinate groupings according to special affinities.

In order not to be misunderstood, I here state, formally, what has been more than once implied in the foregoing, that, while, according to the principle advanced, tetragonal and hexagonal forms depend on the numbers 4 and 3, as explained, the presence of these numbers by no means necessitates the occurrence of these forms. Multitudes of examples illustrate this: the dimorphism of TiO^2 is one. I would also remark that I express no opinion as to whether the molecule of a compound consists of the positive and negative atoms simply juxtaposed, or whether these so-called atoms are composed of particles, and there is a different disposition in the molecule; and assert only that, whatever the fact on this point, there is tetragonal symmetry in the constitution of the molecule in the tetragonal system, and hexagonal in the hexagonal system.

I leave the subject here, without discussing at present the methods by which *orthorhombic* and *clinohedral* forms are produced; only observing that orthorhombic and monoclinic forms occur under all numbers of atoms of the negative element, from 1 (or 2) as in sulphur, upward; and, therefore, although polymerism may turn the 2 of sulphur (and so, other numbers) into various multiples of the same, yet that the production of these forms does not depend simply on numbers.

* See articles I and II referred to on page 89.

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Art. XIII.—*The Glaciers of Alaska, Russian America;* by William P. Blake.*

On approaching the northwest coast of America from the west the mountain chain of the interior is seen to be lofty and alpine in its character. The ridges are sharply serrated, and rise here and there into needle-like pinnacles, giving an outline against the sky that contrasts strongly with the gently sloping sides of the truncated cone of Edgecombe, a fine extinct volcano which marks the entrance to the harbor of Sitka.

The rocky peaks of the interior rise above broad fields of snow, which give birth to numerous glaciers, while Edgecombe, and the ridges upon the coast, are in great part covered with a dense forest of pines and firs. No glaciers are found upon the coast at Sitka or south of it, for under the influence of the warm currents of the Pacific, the climate is comparatively mild, while a short distance in the interior, the winters are almost Arctic in severity.

The principal stream in the vicinity of Sitka, is the Stickeen; which rises in the "Blue Mountains," opposite the head-waters of the Mackenzie, and flows in a general southeasterly direction parallel with the coast until it breaks through the mountains east, and a little north, of Sitka. When the snows are melting, the river becomes much swollen and is then navigable with difficulty by small steamboats for about 125 miles above its mouth. The valley is generally narrow and the river is not bordered by a great breadth of alluvial land.

In ascending this river one glacier after another comes into view; all of them are upon the right bank of the stream and descend from the inner slope of the mountain range. There are four large glaciers and several smaller ones visible within a distance of 60 or 70 miles from the mouth.

The first glacier observed, fills a rocky gorge of rapid descent, about two miles from the river, and looks like an enormous cascade. The mountains are greatly eroded by it, for it is overhung by freshly broken cliffs of rock evidently produced by the glacier.

The second glacier is much larger, and has less inclination. It sweeps grandly out into the valley from an opening between high mountains from a source that is not visible. It ends at the level of the river in an irregular bluff of ice, a mile and a half or two miles in length, and about 150 feet high. Two or more terminal moraines protect it from the direct action of the stream. What

* The observations upon which this article is based were made in May, 1863, while a guest on his Imperial Russian Majesty's Corvette "Rynda," Commander Banarguine, by whose courtesy the writer accompanied Lt. Pereleshin on a reconnaissance, in a whale boat, of the Stickeen river, under the orders of Admiral Popoff. —W. P. B.

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at first appeared as a range of ordinary hills along the river, proved on landing to be an ancient terminal moraine, crescent-shaped, and covered with a forest. It extends the full length of the front of the glacier. The following extract from my notes will answer for a description of the end of this glacier.

We found the bank composed of large angular blocks of granite mingled with smaller fragments and sand. It is an outer and older moraine, separated from a second one by a belt of marshland overgrown with alders and grass, and interspersed with ponds of water. Crossing this low space we clambered up the loose granitic debris of the inner moraine, which is quite bare of vegetation and has a recently formed appearance. These hills are from 20 to 40 feet high, and form a continuous line parallel with the outer and ancient moraine. From their tops we had a full view of the ice cliffs of the end of the glacier, rising before us like a wall, but separated from the moraine by a second belt of marsh and ponds. Here, however, there were no plants or trees. It was a scene of utter desolation. Great blocks of granite lay piled in confusion among heaps of sand or sand-cones or were perched upon narrow columns of ice-glacier tables apparently ready to topple over at the slightest touch. The edges of great masses of ice could be seen around pools of water, but most of the surface was hidden by a deposit of mud, gravel and broken rock. It was evident, however, that all this was upon a foundation of ice, for here and there it was uplifted, apparently, in great masses leaving chasms filled with mud and water. Over this fearful and dangerous place we crossed to the firmer and comparatively unbroken slope of ice at the foot of the bluff, and afterward had to climb over snow and ice only, in the attempt to reach the top of the glacier. From below it had appeared to us to be quite possible to accomplish this if we followed the least broken part of the slope, but it proved to be difficult, and finally impossible. Fissures which could not be seen from a short distance were met at intervals, some of them being so wide that we were forced to turn aside. As we ascended, the crevasses were more numerous but were generally filled with hard snow to which we occasionally trusted. The surface soon became precipitous and broken into irregular stair-like blocks with smooth sides and so large that it was impossible to make our way over them without ladders or tools to cut a foothold. Here we turned and enjoyed the sight of this great expanse of ice, broken into such enormous blocks and ledges. The sun illuminated the crevasses with the most beautiful aquamarine tints, passing into a deep sea-blue where they were narrow and deep. In one direction the ice presented the remarkable appearance of a succession of cones or pyramids with curved sides. In the oppo-

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site direction and at the same level the outlines were totally different, showing merely a succession of terraces or steps inclined

1.

inward toward the glacier and broken by longitudinal crevasses. The annexed sketches were made from this point of view. No. 1 is taken looking up the river, over the end of the glacier, and

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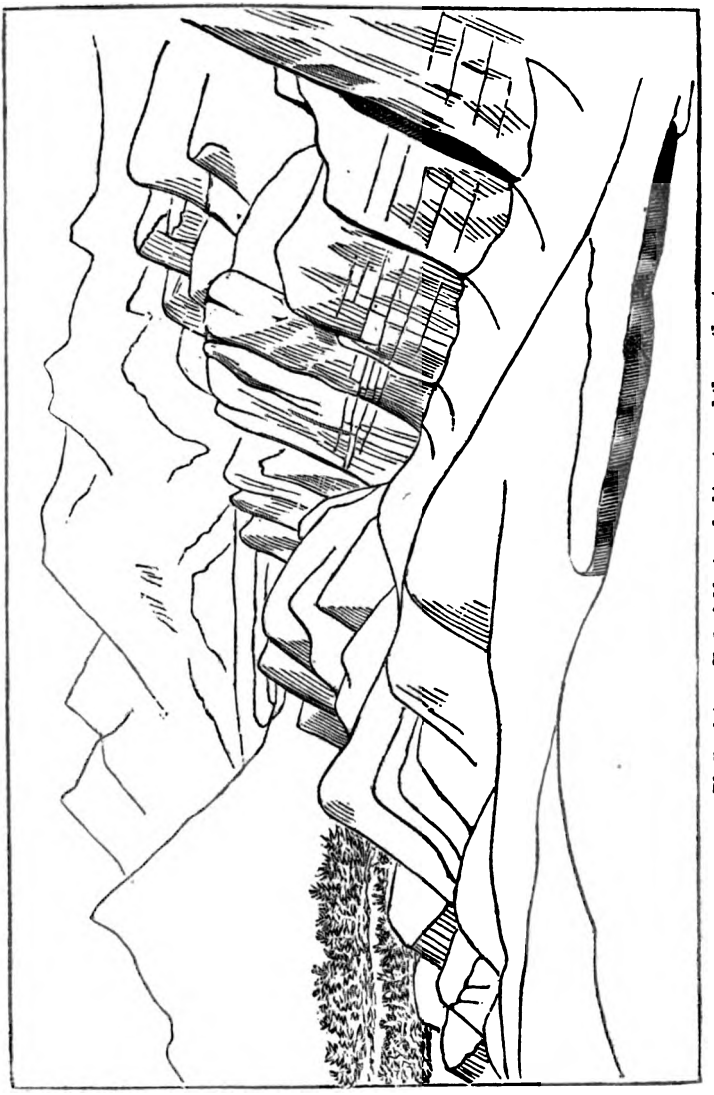
shows the pyramids of ice. The line of ponds, and the two moraines are seen at the base, and the river on the extreme

2.



Bluffs of ice. End of Glacier, looking toward the southeast.

right. No. 2 shows the appearance of the glacier in the opposite direction. A broad fissure between one level of the ice and the next is filled with snow.

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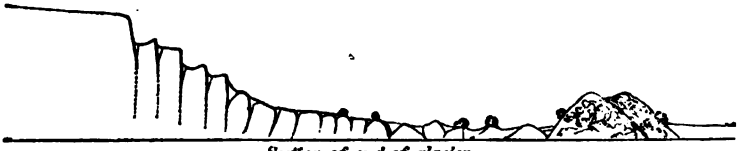
It is evident that this glacier breaks down in a series of great steps or ledges along the greater part of its front. These steps rise for 20 to 30 feet one above the other and thus produce a stair-like ascent, while at the same time the numerous parallel fissures at right angles break the surface into rectangular blocks, which on the side exposed to the sun soon become worn into the pyramids and cones. The difference of outline in opposite directions is thus explained.

I was inclined to regard the melting action of the water of the river as the cause of this abrupt breaking off of the end of the glacier. There may, however, be a sudden break in the rock foundations at this point, so as to produce an ice-cascade. The following section will perhaps give a clearer idea of the manner in which the glacier breaks down.



Section of end of glacier.

One or more streams descend under the glacier, and reach the river at different places. The rushing and roaring sound was rather startling at some of the crevasses.

Judging from the number of loose blocks of rock at the foot of the glacier, the upper surface must be strewn with them, but this could not be verified by observation. Time did not permit a more extended examination. There would be little difficulty in gaining the surface of the glacier from the side, and, perhaps, at some other points along its front. It was impossible to get our Indian guide to accompany us. They have a tradition of the loss of one of their chiefs upon this glacier.

The ancient terminal moraine of this glacier is significant of an amelioration of the climate. It is also interesting to note the effect which this accumulation of materials from the glacier has had upon the river. It has acted as a dam for the waters, setting them back in the valley for some distance.

In this connection the following notes upon the occurrence of great bodies of ice, undoubtedly glaciers, in the more northern parts of Russian America have a special interest.

According to Sir Edward Belcher* the shores of Icy Bay at the foot of Mount St. Elias, lat. 60°, are lined with glaciers. "The whole of this Bay, and the valley above it, was found to be composed of (apparently) snow-ice, about 30 feet in height at the water cliff, and probably based on a low muddy beach." At Cape Suckling in the same latitude and west of Icy Bay the

* Voyage of the Sulphur, i, 78–80.

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same voyager observed a vast mass of ice sloping to the sea, the surface of which presented a most singular aspect, being "one mass of four-sided truncated pyramids." He was not able to account for this and observes "What could produce these special forms? If one could fancy himself perched on an eminence about 500 feet above a city of snow-white pyramidal houses, with smoke-colored flat roofs covering many square miles of surface and rising ridge above ridge in steps, he might form some faint idea of this beautiful freak of Nature."

Vast bodies of ice terminating in cliffs upon the sea are numerous in Prince William Sound, and the thundering noise of the falling of large masses of ice was heard by Vancouver.*

On the shores of an arm of Stephens Passage (northwest of Sitka) a compact body of ice extended for some distance at the time of Vancouver's visit, and from the rugged valleys in the mountains around, immense bodies of ice reached perpendicularly to the sea, so that boats could not land. Similar observations are made, in general, of the mountains of the coast opposite Admiralty island. Two large open bays north and west of Point Couverdeen are terminated by solid mountains of ice rising perpendicularly from the water's edge.

From these various observations we may conclude that the mountain region of Russian and British North America, from latitude 55° to the Polar sea, is dotted with glaciers cutting and scoring the mountains as they descend, and pushing their accumulations of rocky debris either into the ocean, or the rivers of the interior.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the influence of the adhesion of vapor in experiments upon the absorption of heat.*—The subject of the absorption of radiant heat by aqueous vapor has been again taken up by Magnus who has succeeded in pointing out the source of error which affected the experiments of Tyndall and of Wild.† In a previous memoir Magnus had endeavored to shew that vesicular vapor absorbs heat more powerfully than dry air, but that air loaded with transparent vapor has no greater absorptive power than air which contains no vapor at all. Tyndall replied to this paper, and the subject was then examined independently by Wild, who fully confirmed the results of Tyndall. In his new investigation Magnus employed an apparatus of the same dimensions with that of Wild and of similar construction. Experiment soon proved that the walls of the tubes containing the dry or moist air through which the radiant heat passed exercised a

* Vancouver's Voyages, iii, 185, (1794), quoted by Findlay, Directory of Pacific Ocean, i, 479.

† Pogg. Ann., cxxix, 57.

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powerful influence upon the absorption. Thus a tube coated internally with lamp-black produced an effect precisely the opposite of that which was observed when a polished tube was employed. In this case an increase in the amount of heat transmitted was observed when moist air was blown into the tube and a diminution with dry air, while the contrary takes place when a polished tube is used. Magnus proved that a layer of water is deposited upon the inside of the tube throughout its whole length, by shewing that the tube itself becomes warmer whenever moist air is thrown in. This layer of water absorbs more heat than the polished wall of the tube would do if dry, and consequently reflects less to the thermo-electric pile. Experiment showed that the quantity of heat reflected to the pile by the dry wall of a polished brass tube filled with dry air was about six times as great as that which the pile received directly when the tube was removed. Every diminution in the reflecting power of the tube must therefore greatly diminish the quantity of heat received by the pile. In a blackened tube the particles of carbon act as absorbents like the particles of water, only in a higher degree, consequently their absorption is but little increased by the deposition of water.

Hence there is no sensible cooling when moist air is blown into a tube lined with velvet or blackened inside, but on the contrary a rise of temperature which depends on the heat given out by the condensation. By employing two concentric tubes the space between which could be filled with water at different temperatures, Magnus found that when the inner tube had exactly the temperature of the air blown into it, it behaved precisely like the brass tube mentioned above. When the temperature of the inner tube was a few degrees lower than that of the moist air thrown in, the temperature of the pile diminished in a very marked degree, but reached its minimum much more slowly than when the tube had the same temperature as the air thrown in. This doubtless arose from the fact that the greater quantity of condensed vapor made a greater quantity of moist air necessary, the admission of which required a longer time. Further experiments distinctly proved that a condensation of vapor upon the walls of the tube took place even when the moist air blown in was far from its point of saturation. The vapors of alcohol exhibited the same phenomena as those of water, only in a higher degree. In addition, however, it was found that the vapor of alcohol itself exerts a powerful absorbent action upon radiant heat, which is not the case with the vapor of water. The author concludes from his experiments, that the apparent absorption of heat by aqueous vapor observed by Tyndall and Wild is due simply to the effect of the condensation of water upon the sides of the containing tubes, and not to any specific absorptive power in the vapor itself.—*Pogg. Ann.*, cxxx, 207. W. G.

2. *On fluosalts of antimony and arsenic.*—MARIGNAC has examined the action of fluohydric acid upon antimonic and arsenic acids and the corresponding salts. Antimonic acid dissolves in fluohydric acid and gives a fluorid which could not be obtained crystallized but which may be evaporated to a gummy consistency. This fluorid unites readily with alkaline fluorids to form crystalline salts, which are very soluble and more or less deliquescent, their solutions are not precipitated—at least at first—by acids, sulphuretted hydrogen, caustic alkalies, or carbonates. The crys-

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talline salts may be kept without decomposition, but by repeated evaporation they pass into oxyfluoantimonates. The salt SbF_5KF is formed when the gummy antimonate of potash is dissolved in fluohydric acid and the solution evaporated. It crystallizes in thin anhydrous leaves. With an excess of fluorid of potassium this salt gives $SbF_5, 2KF+2H_2\Theta$ in beautiful very brilliant prisms derived from an oblique rhombic prism. A fluo-oxyantimonate of sodium $Sb\Theta F_3, NaF+H_2\Theta$ is obtained by adding carbonate of soda to a solution of fluorid of antimony in an excess of fluohydric acid and separates in small deliquescent hexagonal prisms. When this last salt is dissolved in fluohydric acid, another crystalline soda salt is obtained having the formula SbF_5, NaF. Two crystalline ammonium salts have respectively the formulas SbF_5, NH_4F and $2(SbF_5, 2NH_4F)+H_2\Theta$.

The fluo-arsenates are still more easily soluble than the fluo-antimonates and therefore more difficult to obtain pure. Marignac describes crystalline salts having respectively the formulas $2(AsF_5, KF)+H_2\Theta$; $As\Theta F_3, KF+H_2\Theta$; $AsF_5, 2KF+H_2\Theta$; and $As_2\Theta F_3, 4KF+3H_2\Theta$; which last is perhaps $As\Theta F_3, 2KF+AsF_5, 2KF+3H_2\Theta$.—*Zeitschrift für Chemie*, iii, 107. W. G.

[*Note.*—The salts described by Marignac are of special interest as showing the relationship of niobium and tantalum to the nitrogen group. A comparison of the formulas of the fluorine compounds of arsenic and antimony with those of niobium and tantalum already described in this Journal will remove any doubt as to the pentatomic character of the metals last named, and as to the natural group of elements to which they belong.—W. G.]

3. *Action of the hydracids upon ethers.*—GAL has shown that the action of the hydracids upon both simple and compound ethers, is precisely analogous to that which these acids exert upon the anhydrids, already published by him.

If we let *A* represent a negative or acid radical, and *B* a positive or alcoholic one, the formation of a compound ether may be expressed thus:

$$ACl+\left.\begin{matrix}B\\H\end{matrix}\right\}\Theta=\left.\begin{matrix}B\\A\end{matrix}\right\}\Theta+HCl.$$

Now it is evident that the reaction in the inverse direction will be

$\left.\begin{matrix}B\\A\end{matrix}\right\}\Theta+HBr=\left.\begin{matrix}A\\H\end{matrix}\right\}\Theta+BBr$: rather than $\left.\begin{matrix}B\\A\end{matrix}\right\}\Theta+HBr=\left.\begin{matrix}B\\H\end{matrix}\right\}\Theta+ABr$; since in the latter case we return to our starting point. To confirm this theoretic view, Gal undertook the present research.

In these experiments, hydrobromic acid was the acid generally used; and the compound ethers employed were those formed with methyl and ethyl, by the fatty acid series $\mathfrak{C}_nH_{2n}\Theta_2$; the aromatic acid series, $\mathfrak{C}_nH_{2n-8}\Theta_2$; the oxalic acid series, $\mathfrak{C}_nH_{2n-2}\Theta_4$; the carbonic acid series, $\mathfrak{C}_nH_{2n}\Theta_3$; and by nitric acid. The ether was saturated with hydrobromic acid gas, and exposed in a sealed tube, to an elevated temperature for some hours. And in every case the decomposition was found to take place according to the equation given above, methylic or ethylic bromid being produced, and the acid of the ether being set free.

On the alcohols, hydrobromic acid acts thus:—

$$\left.\begin{matrix}B\\H\end{matrix}\right\}\Theta+HBr=\left.\begin{matrix}H\\H\end{matrix}\right\}\Theta+BBr,$$

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showing that we may consider alcohols as compound ethers, in which hydrogen acts the part of a negative radical. With the simple ethers, if the hydrobromic acid be in excess we have:—

$$\left.\begin{matrix}B\\B\end{matrix}\right\}\Theta+(\mathrm{HBr})_2=\left.\begin{matrix}\mathrm{H}\\\mathrm{H}\end{matrix}\right\}\Theta+(B\mathrm{Br})_2,$$

but if the ether be in larger proportion, then

$$\left.\begin{matrix}B\\B\end{matrix}\right\}\Theta+\mathrm{HBr}=\left.\begin{matrix}B\\\mathrm{H}\end{matrix}\right\}\Theta+B\mathrm{Br}.$$

The mercaptans give rise to two reactions. First we have

$$\left.\begin{matrix}B\\\mathrm{H}\end{matrix}\right\}\mathrm{S}+\mathrm{HBr}=\left.\begin{matrix}\mathrm{H}\\\mathrm{H}\end{matrix}\right\}\mathrm{S}+B\,\mathrm{Br},$$

and secondly $\left.\begin{matrix}B\\\mathrm{H}\end{matrix}\right\}\mathrm{S}+(B\,\mathrm{Br})_2=\left.\begin{matrix}B\\B\\B\\\mathrm{Br}\end{matrix}\right\}\mathrm{S}+\mathrm{HBr}$. The simple sulphur ethers act similarly; the first reaction is $\left.\begin{matrix}B\\B\end{matrix}\right\}\mathrm{S}+\mathrm{HBr}=\left.\begin{matrix}B\\\mathrm{H}\end{matrix}\right\}\mathrm{S}+B\mathrm{Br}$, the second $\left.\begin{matrix}B\\\mathrm{H}\end{matrix}\right\}\mathrm{S}+\mathrm{BBr}=\left.\begin{matrix}B\\B\\B\\\mathrm{Br}\end{matrix}\right\}\mathrm{S}$, as Cahours has also shown.—*Ann. Ch. Phys.*, IV, x, 5.

4. *On new mixed acids.*—In a more recent paper, Gal has described some new mixed acids which he has produced. Reasoning from the well known fact that by the action of potassic hydrate upon monobromacetic acid, glycollic acid is formed, according to the equation

$$\mathrm{C}_2\widehat{\mathrm{H}_2}\mathrm{Br}\left.\begin{matrix}\Theta\\\mathrm{H}\end{matrix}\right\}\Theta+\left.\begin{matrix}\mathrm{K}\\\mathrm{H}\end{matrix}\right\}\Theta=\mathrm{C}_2\widehat{\mathrm{H}_2}(\mathrm{H}\Theta)\left.\begin{matrix}\Theta\\\mathrm{H}\end{matrix}\right\}\Theta+\mathrm{KBr},$$

(or, as is more clearly exhibited in Frankland's notation,

$$\left\{\begin{matrix}\mathrm{C}\mathrm{H}_2\mathrm{Br}\\\mathrm{C}\Theta\,\mathrm{Ho}\end{matrix}\right.+\mathrm{KHo}=\left\{\begin{matrix}\mathrm{C}\mathrm{H}_2\mathrm{Ho}\\\mathrm{C}\Theta\mathrm{Ho}\end{matrix}\right.+\mathrm{KBr}),—$$

the change being the substitution of Ho(=HΘ, hydryl) for Br,—Gal concluded that the similar univalent radical oxacetyl,* in potassic acetate, might be similarly exchanged. Though in the discovery of such mixed acids, Gal has been anticipated by Strecker, Wurtz and others, he has in the present research added several new ones to the list.

By heating to 100° C. in a sealed tube, an alcoholic solution of ethylic monobromacetate with potassic acetate, he obtained a liquid having a density about 1, whose boiling point was 180° C., and whose formula, as given by analysis, was $\mathrm{C}_6\mathrm{H}_{10}\Theta_4$. When heated in a sealed tube with an alcoholic solution of potassic hydrate, it was decomposed, yielding potassic acetate and glycollate, and alcohol. If it be treated with solid potash, and distilled, acetic ether passes over, and potassic glycollate remains in the retort. From these reactions, Gal infers that the liquid above mentioned is the ether of an acid formed from glycollic acid by replacing its hydryl by the radical oxacetyl, and which he calls aceto-glycollic acid. Its formation is thus represented: $\left\{\begin{matrix}\mathrm{C}\mathrm{H}_2\mathrm{Br}\\\mathrm{C}\Theta\mathrm{Eto}\end{matrix}\right.+\left\{\begin{matrix}\mathrm{C}\mathrm{H}_3\\\mathrm{C}\Theta\mathrm{Ko}\end{matrix}\right.=\left\{\begin{matrix}\mathrm{C}\mathrm{H}_2\mathrm{Aco}\\\mathrm{C}\Theta\mathrm{Eto}\end{matrix}\right.+\mathrm{KBr}.$

* Oxacetyl, Aco=($\mathrm{C}_2\mathrm{H}_3\Theta_2$).

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By alcoholic potash it breaks up thus:

$$\left\{\begin{matrix}\text{CH}_2\text{Aco}\\ \text{C}\Theta\text{Eto}\end{matrix}\right. + (\text{KHo})_2 = \left\{\begin{matrix}\text{CH}_2\text{Ho}\\ \text{C}\Theta\text{Ko}\end{matrix}\right. + \left\{\begin{matrix}\text{CH}_3\\ \text{C}\Theta\text{Ko}\end{matrix}\right. + \left\{\begin{matrix}\text{CH}_3\\ \text{CH}_2\text{Ho}\end{matrix}\right..$$

By solid potash as follows: $\left\{\begin{matrix}\text{CH}_2\text{Aco}\\ \text{C}\Theta\text{Eto}\end{matrix}\right. + \text{KHo} = \left\{\begin{matrix}\text{CH}_2\text{Ho}\\ \text{C}\Theta\text{Ko}\end{matrix}\right. = \left\{\begin{matrix}\text{CH}_3\\ \text{C}\Theta\text{Eto}\end{matrix}\right..$

The ordinary compound ethers when distilled with potash, produce alcohol, and a salt of the acid they contain; while these mixed-acid ethers yield either a salt and a more simple ether; or two salts and alcohol.

This view of its constitution, Gal proposed to confirm by submitting the new ether to the action of the hydracids according to the method given in the preceding section. He saturated therefore several grams of this aceto-glycollic ether with hydrobromic acid gas, and heated to 100° C. After repeating this process several times, the product was distilled on the water bath. The distillate was pure ethylic bromid. A viscous mass was left in the retort which upon examination proved to be a mixture of acetic and monobromacetic acids; the action of the hydracid being $\left\{\begin{matrix}\text{CH}_2\text{Aco}\\ \text{C}\Theta\text{Eto}\end{matrix}\right. + (\text{HBr})_2 = \text{Et Br} + \left\{\begin{matrix}\text{CH}_2\text{Br}\\ \text{C}\Theta\text{Ho}\end{matrix}\right. + \left\{\begin{matrix}\text{CH}_3\\ \text{C}\Theta\text{Ho}\end{matrix}\right.$ in perfect accordance with the generalization above given.

Gal prepared also ethylic butyro-glycollate, $\left\{\begin{matrix}\text{CH}_2\text{Buo}\\ \text{C}\Theta\text{Eto}\end{matrix}\right.$, by treating potassic butyrate with ethylic monobromacetate; ethylic butyro-butyllactate (better butyro-oxybutyrate), $\left\{\begin{matrix}\text{CEtHBuo}\\ \text{C}\Theta\text{Eto}\end{matrix}\right.$; and ethylic aceto-oxybutyrate $\left\{\begin{matrix}\text{CEtHAco}\\ \text{C}\Theta\text{Eto}\end{matrix}\right.$. The last is isomeric with butyro-glycollic ether, both containing $\text{C}_7\text{H}_{14}\Theta_4$. The number of mixed acids which can thus be formed is, as Gal observes, very great; especially when not only the mono-brominated fatty acids, but also the di- and tribrominated bodies of this series are used as starting points.—*Bull. Soc. Ch.*, II, vii, 329, April, 1867.

5. *On some new compounds of silicon.*—In a series of researches upon silicon and its compounds, made some years ago by Wöhler and Buff, they obtained, by passing hydrochloric acid gas over crystallized silicon heated to a temperature just below redness, a very volatile liquid, boiling at 42° C. and yielding an inflammable vapor. This liquid was decomposed by water, with the production of a white substance, differing entirely from silica in its properties. To the volatile liquid these chemists gave the formula $\text{Si}_2\text{Cl}_3 + 2\text{HCl}$; and to the white body the corresponding formula $\text{Si}_2\text{O}_3 + 2\text{HO}$, (Si=21).* More recently, however, Wöhler assigned to these bodies the formulæ $\text{Si}_6\text{H}_4\text{Cl}_{10}$ and $\text{Si}_6\text{H}_4\text{O}_{10}$ respectively† (Si=14.) The authors observe that the above compounds may not have been absolutely pure when analyzed, and call upon chemists having more leisure to re-examine the whole subject.

This investigation has been undertaken by Friedel and Ladenburg. In the first place, they thought it improbable from theoretical considerations, that so volatile a body as the above chlorid should have so complicated a molecule; and from its method of preparation they inferred that

* Ann. Ch. Pharm., civ, 94. This Journal, II, xxv, 270, 1858.

† Ib., cxxvii, 257. This Journal, II, xxxvii, 120, 1864.

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it might be silicic chlorid, in which an atom of hydrogen had replaced one of chlorine. If they could not separate the body in question from the silicic chlorid formed at the same time, by fractional distillation, they were prepared to convert both into ethers and thus to effect the separation.

The compound was prepared by Wöhler and Buff's method. And they found that by subjecting the crude material to a series of careful fractionings, a liquid was obtained whose boiling point was 34° C. instead of 42°, and which distilled entirely between 34° C. and 37·5°. As thus purified, the liquid possessed all the properties mentioned by Wöhler and Buff. Its vapor mixed with air detonated violently in contact with flame, giving a white cloud of silica. It was analyzed by placing a weighed quantity in a sealed bulb, introducing this into a tube containing dilute ammonia, sealing the tube, and breaking the bulb. After a short time the tube was opened, its contents poured into a platinum dish and evaporated to dryness on the water-bath. The residue was treated with water, filtered, ignited and weighed; and by subtracting from the entire weight, that of the glass of the bulb, that of the silica was obtained. In the filtrate the chlorine was determined as usual. The results lead to the formula $SiCl_3H$, (Si=28.) That this formula moreover, represents the size of the molecule was proved by the vapor density; experiment giving 4·64, while theory requires 4·69. The hypothesis of its composition is thus confirmed; and they showed farther that at ordinary temperatures chlorine transforms it into silicic chlorid, $SiCl_4$; while at a red heat hydrogen acts upon $SiCl_4$, converting a portion of it into $SiCl_3H$.

When this substance is mixed with absolute alcohol, a large quantity of hydrochloric acid gas is evolved, and the resulting liquid, when subjected to fractional distillation, yields two bodies, one of which boils between 134° and 137°, and the other at 165° C. The latter body is silicic ether; the former is an ether corresponding to the chlorid above described. Its analysis gives the formula $SiC_6H_{16}O_3$, from which the authors derive the constitutional formula $\left.\begin{matrix}(SiH)''' \\ (C_2H_5)_3\end{matrix}\right\}O_3$. When silicic chlorid $SiCl_4$ acts upon alcohol, it produces silicic ether $\left.\begin{matrix}Si \\ (C_2H_5)_4\end{matrix}\right\}O_4$, as is well known; consequently the new ether bears the same relation to the volatile chlorid, that silicic ether bears to silicic chlorid. It is a limpid liquid, with an agreeable odor, and insoluble in water, by which it is slowly decomposed. It is rather more inflammable than silicic ether, and differs from it by evolving hydrogen when treated with an alcoholic solution of ammonia.

The action of sodium upon this ether is quite remarkable. When first introduced, a slight evolution of gas is perceived, due probably to the trace of alcohol present, produced by the action of atmospheric moisture on the chlorid. But if the mixture be gently heated, there is a uniform evolution of gas which upon examination proved to be pure hydric silicid or siliciuretted hydrogen. After allowing the first portions of the gas to escape, it may be collected for analysis. This was effected by placing a measured quantity in a graduated bell over mercury, and then passing up a concentrated solution of potash. The evolution of gas commenced at once; and, when the action ceased the volume was measured. It was found to occupy four times the volume of the original gas, and to burn

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with the pale flame characteristic of hydrogen. The action of the potash then is as follows: $(HK\Theta)_4+SiH_4=K_4SiO_4+H_8$, from which it appears that one half the hydrogen comes from the potassic hydrate, the other half from the silicid. As 2 vols. of the latter increase to 8 vols. in the above experiment, they evidently furnish 4 vols. of hydrogen; and since an atom of hydrogen occupies one volume, and a molecule of silicid 2 volumes, it is evident that each molecule of the latter contains 4 hydrogen atoms, and that its formula is SiH_4. This is the formula assigned to it by Wöhler and Buff, its original discoverers; though they never obtained it pure, but always mixed with free hydrogen. The liquid which results from the action of the sodium, is pure ethylic silicate. The sodium appears to take no part in the reaction, since it remains white and metallic, and does not diminish in weight. The formation of the hydric silicid may therefore be thus represented:

$$\left(\left.\begin{matrix}(SiH)'''\\(C_2H_5)_3\end{matrix}\right\}\Theta_3\right)_4=SiH_4+\left(\left.\begin{matrix}Si\\(C_2H_5)_4\end{matrix}\right\}\Theta_4\right)_3.$$

The gas thus obtained is not spontaneously inflammable, at the ordinary atmospheric temperature and pressure. But if into a small quantity of it confined in a tall jar over mercury,—so that the mercury column considerably lessens the pressure,—a few bubbles of air be passed, ignition takes place with deposition of silicon mixed with silica. In this respect the gas behaves like hydric phosphid; and the authors suggest that the hydrogen mixed with the SiH_4 of Wöhler and Buff, may be the cause of its spontaneous inflammability. A hot knife blade placed near the bubbles as they rise through the mercury, inflames them with a slight explosion.

Friedel and Ladenburg have also examined the white substance produced by the action of water on the inflammable chlorid. It was prepared by passing the vapor of this chlorid into water at zero. The product was washed with ice-cold water, dried, first in a vacuum over sulphuric acid, and then in an oil bath at 150° to 180° C. and analyzed. The results give the formula $Si_2H_2\Theta_3$, from which the authors derive the rational formula $\left.\begin{matrix}SiH\Theta\\SiH\Theta\end{matrix}\right\}\Theta$. Its production is expressed thus:

$$((SiH)Cl_3)_2+(H_2\Theta)_3=\left.\begin{matrix}SiH\Theta\\SiH\Theta\end{matrix}\right\}\Theta+(HCl)_6.$$

These researches confirm the opinion originally advanced by Wöhler that these compounds are analogous to organic bodies, and consequently prove the analogy of silicon and carbon. It will be noticed that the inflammable chlorid $(SiH)Cl_3$ is similar to chloroform $(CH)Cl_3$; that the compound $\left.\begin{matrix}(SiH)'''\\(C_2H_5)_3\end{matrix}\right\}\Theta_3$ corresponds precisely to the tribasic formic ether of Kay $\left.\begin{matrix}(CH)'''\\(C_2H_5)_3\end{matrix}\right\}\Theta_3$; that hydric silicid SiH_4, is analogous to hydric carbid CH_4; and that the body $\left.\begin{matrix}SiH\Theta\\SiH\Theta\end{matrix}\right\}\Theta$ is identical in structure with formic anhydrid $\left.\begin{matrix}CH\Theta\\CH\Theta\end{matrix}\right\}\Theta$. For this reason, Friedel and Ladenburg propose the name *silici-chloroform* for the first substance, *tribasic silici-formic ether* for the second, and *silici-formic anhydrid* for the last. The quadrivalence of silicon seems therefore as firmly established as that of carbon itself.—*Bull. Soc. Ch.*, II, vii, 322, April, 1867.

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6. *Crystallization of graphitoidal silicon.*—Professor W. H. MILLER has examined some crystals of graphitoidal silicon, so called, which were received from Dr. Percy. They appeared to be oblique; but on measurement, they were found to be regular octahedrons, in which two parallel faces were much larger than the others; two other parallel faces were either too small to be observed or were altogether wanting. One of these scales had the faces of a twin octahedron. He concludes therefore, that there is no crystallographic reason for separating the graphitoidal from the ordinary octahedral variety of silicon.

He also considers it probable that graphitoidal boron, recently shown by Wöhler and Deville to be an aluminic borid, is tetragonal, as Sella has shown the adamantine boron to be. Sella views even the latter variety as a definite compound of boron with aluminum and carbon, mechanically mixed with pure boron.—*Phil. Mag.*, IV, xxxi, 397, May, 1866.

7. *Density of Ozone.*—At the meeting of the French Academy on the 6th of May, REGNAULT communicated a note from Soret of Geneva, upon the density of ozone. As previously determined by this chemist, the density of this substance obtained in absorption experiments, is one and a half times that of oxygen. He has now re-determined it by means of Graham's law of diffusion; i. e., the velocity of diffusion of a gas is inversely as the square root of its density. He ascertained the coefficient of diffusion of chlorine into oxygen and of ozone into oxygen. He found that in 45 minutes, for every cubic centimeter of chlorine contained in one of the two diffusion tubes, 0·227 of chlorine diffused into the upper tube, while for ozone, the quantity under the same circumstances was 0·271. Now the ratio ·227 : 271=·8382 : 1; and if we assume ozone to have one and a half times the density of oxygen, Graham's law would give us $\sqrt{35{\cdot}5} : \sqrt{24} = 1 : {\cdot}8222$, a remarkably close approximation, considering the difficulties of the method. We may therefore fairly regard the density of ozone as one and a half times that of oxygen; or 1·657 if air be taken as 1, and 24 if hydrogen be unity. While therefore the molecule of free oxygen contains two atoms, that of ozone contains three.—*The Laboratory*, i, 121, May 18, 1867.

9. *Adamantine anthracitic carbon.*—In the name of M. le Comte de Douhet, Dumas presented recently to the Academy of Sciences at Paris some nodules of mineral carbon, remarkable for their hardness. They were found by Douhet in the hands of a merchant, who supposed them to come from Brazil, but their origin and mode of occurrence are not certainly known. These nodules consist of irregularly concentric layers. When cut and polished on the lapidary's wheel, they acquire a surprising luster. Even in the thinnest fragments the mineral is opaque. Its density is 1·66. A preliminary analysis by Friedel showed the presence of 11 per cent of ash; thus raising the question whether the hardness is not due to foreign impurities. Dumas therefore examined purer fragments, and found the quantity of ash 4 per cent in two specimens; one being the crude material, the other the same after pulverization and washing. Hence the ash is uniformly distributed through the mass. Moreover this ash is neutral in its reactions, and neither scratches nor abrades glass. Two elementary analyses gave Dumas, as a mean, the following composition: carbon 97·5, hydrogen 0·5, oxygen 1·5, ash 0·5=100.

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This it will be noticed is the composition of anthracite. In a subsequent letter to Les Mondes, M. le Comte de Douhet, thus describes the mineral: The nodules are globular, mammillated, consisting of concentric layers, and occasionally possessing a nearly perfect cleavage. Though fragile and brittle, the fragments will scratch not only the hardest gems, but also the diamond itself; though ordinary anthracite will not scratch even glass. When facets are cut upon it, this singular mineral refracts and disperses light with that white luster which is characteristic of the diamond; other and colored gems reflect light tinged with color; while the brilliance of the diamond is always white, even when it is itself colored. Prismatic colors appear only when the light is refracted in the interior of the crystal. This mineral, being opaque, cannot decompose light, though it actively disperses it. These properties of hardness and luster contrast strangely with the feeble density, anthracitic appearance, and composition of this substance.

At the next session of the Academy, Dumas read a note from Mène, calling attention to some specimens of carbon presenting a similar appearance, which he had obtained artificially by heating in the muffle of a cupel furnace for a long time the anthracite coal of Creuzot. It thus acquires a metallic luster, steel-gray color, and scratches glass and steel with the cry of the diamond. Its density is 1·637, and its composition is carbon 96·8, volatile matter 1·0, ash 2·2=100. Mène also states that the coke produced from a mixture of the Creuzot anthracite with the St. Etienne bituminous, contains a multitude of brilliant points which readily scratch glass.—*Comptes Rendus*, lxiv, 547 and 674; *Les Mondes*, Apr. 11, 1867.

10. *On the origin of meteorites.*—In his researches on diffusion, GRAHAM has shown that certain metals, such as iron, platinum, and gold, which occur native in the soft colloid condition, readily absorb or occlude gases. Hence by examination of the gases evolved from a meteorite for example, the character of the atmosphere through which the ignited mass has passed, may be determined. The well known Lenarto meteorite is admirably adapted for such an experiment, being very pure and soft. A piece 50 millimeters long, 13 wide and 10 thick, was cut from the mass, cleansed and placed in a porcelain tube connected with a Sprengel aspirator. The tube was then heated in an ordinary combustion furnace by ignited charcoal. Gas was freely evolved, which in 2½ hours amounted to 16·53 cubic centimeters. This gas burned like hydrogen, and when analyzed gave 85·68 hydrogen, 4·46 carbonic oxyd, 9·86 nitrogen in the 100. As the volume of the iron was 5·78 c.c., it appears to yield 2·85 times its volume of gas, of which 86 per cent is hydrogen. Now, since hydrogen has been shown by spectrum analysis to be present in the fixed stars, and by Secchi to be a principal element in some of them, we may fairly suppose that the Lenarto meteorite has brought to us the hydrogen of those distant bodies. Moreover it is found that malleable iron can scarcely be made to occlude more than its own volume of hydrogen under the ordinary atmospheric pressure. But the meteorite gave three times this quantity. Hence Graham infers that it must have originated beyond the limits of the light cometary matter of our solar system.—*Chem. News*, May 31, 1867.

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11. *Action of manganic peroxyd on uric acid.*—C. GILBERT WHEELER finds that when uric acid is warmed with water and manganic peroxyd, and sulphuric acid added in small portions, so long as any action is observed, the filtrate yields on concentration, crystals of parabanic acid. But that if the mixture of water and uric acid be treated with the peroxyd so long as carbonic dioxyd is evolved, and the whole filtered, manganic oxalate is left on the filter, and the filtrate contains allantoin and urea. He gives the reaction as follows:

$$(C_5H_4N_4O_3)_3+(MnO_2)_3+(H_2O)_4=(C_4H_6N_4O_3)_2+(COH_4N_2)_2+(MnC_2O_4)_2+MnCO_3.$$—*From the author's paper in the Zeitschrift für Chemie.*

12. *Indium.*—Fremy exhibited to the Academy on the 22nd of April, in behalf of Professor Richter who was present, two ingots of indium obtained from the Freiberg blendes, which were about a decimeter high, and a few centimeters in diameter, and weighed 500 grams. They were valued at 20,000f.

13. *Expansion of metals and alloys by heat.*—A. MATTHIESSEN has applied the hydrostatic method—by means of which he determined the expansion of water and mercury (see this Journal, II, xliii, 254)—to metals and alloys. The unit of volume at 0° C. becomes at t° C.,

$$V_t=1+\frac{a}{10000}t+\frac{b}{1000000}t^2,$$

and is at 100° C. equal to $1+c$. The values of a, b, and c determined by him are as follows:

	a.	*b.*	*c.*
Cadmium,	0·3078	0·140	0·009478
Zinc,	·3222	·070	3925
Lead,	·3177	·0222	3399
Tin,	·6100	·0789	6889
Silver,	·5426	·0405	5831
Copper,	·4443	·0555	4998
Gold,	·4075	·0336	4411
Bismuth,	·3502	·0446	3948
Palladium,	·3032	·0280	3312
Antimony,	·2770	·0397	3167
Platinum,	·2554	·0104	2658

He investigated the following 19 alloys: 1. Sn_4Pb; 2. Pb_4Sn; 3. CdPb; 4. Sn_4Zn; 5. Sn_6Zn; 6. $Bi_{44}Sn$; 7. $BiSn_2$; 8. $Bi_{24}Pb$; 9. $BiPb_2$; 10. Cu+(33·85 vol.) Zn; 11. $AuSn_2$; 12. Au_2Sn_7; 13. Ag_4Au; 14. AgAu; 15. $AgAu_4$; 16. Ag+(19·65 vol.) Pt; 17. Cu+(48·06 vol.) Au; 18. Cu+(28·31 vol.) Ag; 19. Cu+(73·13 vol.) Ag.

The volume at 100° C. was determined as above and also calculated from that of the component metals; he obtained also the specific gravity, and in an earlier investigation the electric conductibility. The results thus obtained are:

No. of Alloy.	Volume at 100° C. Observed.	Volume at 100° C. Calculated.	Specific gravity. Observ.	Specific gravity. Calc.	Conductibility. Observ.	Conductibility. Calc.
1.	1·007188	1·007225	8·188	8·203	10·57	10·63
2.	8419	8129	10·590	10·645	8·28	8·43
3.	9138	8847	10·246	10·246	12·61	13·72
4.	7164	7144	....	....	13·22	13·45
5.	7058	7066	....	....	12·66	12·64

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No. of Alloy.	Volume at 100° C. Observed.	Calculated.	Specific gravity. Observ.	Calc.	Conductibility. Observ.	Calc.
6.	4064	3972	9·803	9·801	0·245	1·28
7.	5098	5207	8·772	8·738	3·96	5·59
8.	4086	4026	9·845	9·850	0·257	1·30
9.	8621	6007	10·956	10·541	2·09	4·23
10.	5719	6328	....	....	21·71	70·20
11.	4233	5919	11·833	11·978	14·27	35·51
12.	4423	6223	....	....	6·00	28·25
13.	5166	5549	12·257	12·215	20·93	94·62
14.	4916	5123	14·870	14·847	14·59	86·52
15.	4300	4693	17·540	17·493	20·91	78·38
16.	4568	5207	....	....	6·70	83·60
17.	4657	4716	....	....	12·00	83·25
18.	5436	5233	....	....	67·85	95·00
19.	5718	5607	....	....	63·00	98·20

The volume at 0° C. being 1. From these tables Matthiessen concludes that the volume (as well as the specific gravity) of any alloy between 0° and 100° C. nearly equals the mean of the volumes of the alloyed metals at the given temperature. In other words, neither volume nor specific gravity depends on the *chemical* nature of the alloy; while the last two columns show that the electric conductibility, not being simply the calculated mean, does depend on the chemical condition of the alloy. In his concluding remarks, Matthiessen states that he is able to calculate the conductibility of any alloy if it be considered as a "solidified solution of one metal in the other."—*Pogg. Annalen*, 1867, cxxx, 50–76; *Cosmos*, 1867, v, 160. G. H.

14. *Undulatory theory of heat.*—Babinet says that his theory, first published in 1838 is still new; we give the following extract from L'Institut, 1866, pp. 340–342.

The heat of a molecule is its vis-viva; two molecules are in caloric equilibrium when they possess the same vis-viva. In this condition they will, either at a distance or in contact exchange equal quantities of heat, and if placed in the same sphere, they will produce the same radiation.

If Θ represents the mass of a molecule of oxygen having a velocity v, and H and v', the same quantities for hydrogen; then these molecules have the same quantity of heat and the same temperature if

$$\Theta v^2 = \mathrm{H} v'^2.$$

As $\Theta = 16\mathrm{H}$, we have $v' = 4v$.

For any two atoms m and m' with the velocities v and v' we have likewise

$$mv^2 = m'v'^2.$$

At any other temperature these atoms are still in equilibrium if their new velocities of vibration u and u' fulfill

$$mu^2 = m'u'^2.$$

Consequently $mv^2 - mu^2 = m'v'^2 - m'u'^2$.

That is, the two atoms gain or lose the same quantities of heat between two given temperatures. Or in other words, *the specific heat of elementary atoms is constant*, which is the law of Dulong and Petit.

According to Babinet, all molecules, vibrating separately, have the same vis-viva and heat, independent of the state of aggregation of the body (solid, liquid or gaseous). Hence the *unit of heat*—or one *dynamic calory*—is the excess of vis-viva of any molecule at 1° C. above

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that which it has at 0° C. At this temperature, 0°, the total quantity of vis-viva of the molecule is very nearly 1200 such units.

By *combining* two molecules so that they vibrate as one, Babinet proves that their vis-viva will be doubled; or if the final temperature is to be the original temperature, the combination must lose a vis-viva equal to that originally possessed by each of the molecules, or 1200 dynamic calories (?).

The demonstration of the law of Dulong and Petit is favorable to the peculiar views of Babinet; but we must await further developments before we can form an intelligent opinion concerning the other parts of his paper. G. H.

15. *Action of heat on the optical properties of crystals.*—DesCloizeaux has determined optically the system of crystallization for quite a number of minerals, hitherto imperfectly ascertained, and has also made some very important observations on the variation of the optical properties of crystals by heat. He finds:

(1.) On the optical properties of *uniaxial* crystals heat seems to have no influence. Crystals which, by some irregularity of structure, show an open cross (croix disloquée) resembling the hyperbolic branches of biaxial crystals, did not show any variation even by a change in temperature from 10° to 190° C. Anatase, apophyllite, beryl, idocrase, tourmaline, were among the crystals examined.

(2.) In *biaxial* crystals the apparent distance of the axes is generally changed by a change of temperature; so that the three indices of refraction are probably unequally modified by heat. Fizeau has shown by direct determinations that the indices of refraction of the ordinary and extraordinary rays in uniaxial calcite and quartz are thus unequally modified by heat. The amount of displacement of the axes, as well as the dispersion, are very different for different substances, but have not as yet been found related to other optical properties. DesCloizeaux found among 72 orthorhombic crystals—

		Displacement.	Dispersion.
19	showed	great,	great.
10	"	feeble,	considerable.
4	"	insensible,	considerable.
10	"	considerable,	feeble.
12	"	feeble,	very small.
17	"	insensible or uncertain,	very feeble or nearly zero.

Aragonite and the micas show exceedingly small variation. Celestine (increase of 6° 41′ between 10° and 105° C.) and leadhillite (diminution of 16° 50′ between 15° and 180°) are among the more variable.

(3.) While in the orthorhombic forms the median line of the optical axes remains unchanged, *it does change in most monoclinic crystals*, as already found by Neumann, in 1835, for gypsum. Among 22 such crystals with the optical axes in the plane of symmetry, and heated between 15° and 200° DesCloizeaux found that 11 showed a considerable, 6 showed a feeble or hardly sensible, 5 showed hardly any change in the median line.

(4.) The five triclinic minerals investigated (albite, amblygonite, axinite, disthene, sassoline) showed between 15° and 175° C. hardly any change in either the distance or the plane of their optical axes.—*L'Institut*, 1866, pp. 139–141. G. H.

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16. *On the determination of atomic weights by optical means;* by Dr. ALBRECHT SCHRAUF.—If μ be the index of refraction and d the density of a body, then Newton's formula for the *refractive power* M of any substance is by Schrauf replaced by

$$M=\frac{A^2-1}{d}, \qquad N=\frac{B}{d^2}, \qquad \mu=A+\frac{B}{\lambda^2},$$

where λ is the wave-length, N the *dispersing power*.

Schrauf modifies the latter equation of Cauchy to $\mu=1+\frac{C'}{\lambda^2}$, where C′ is a constant, and uses A as the numerical value of μ for $\lambda=\lambda_\varrho$, the wave-length of the red rays. For the correctness of this modified relation between μ and λ he gives good theoretical and experimental proof.

If P be the atomic weight of an element, then $\mathbf{M}=PM$ and $\mathbf{N}=PN$ are respectively what he calls the *refraction-* and *dispersion-equivalents.* Moreover, by considering light to be a vibratory motion of the atoms, he deduces

$$\mathbf{M} \text{ proportional to } ZG,$$

where Z is the number and G the magnitude of the "physical atoms."

$\mathbf{M}$ of any element he determines by μ in the different conditions of aggregation, and also indirectly from the several compounds it forms. In the latter case he subtracts $\mathbf{M}$ (Pars) or the refraction-equivalent of the other parts from that of the substance entire, $\mathbf{M}$ (Tot);

$$\mathbf{M}\,(x)=\mathbf{M}\,(\text{Tot})-\mathbf{M}\,(\text{Pars}).$$

For any compound of a, b, c, etc., he puts

$$\mathbf{M}(a+b+c+\ldots)=n\mathbf{M}(a)+n'\mathbf{M}(b)+\text{ etc.},$$

where n, n' . . . are simple, entire numbers.

The following is a synopsis of the principal results. P are the *atomic* weights as now adopted.

Elements uncombined; μ directly determined.

Gas:	Hydrogen,	M=0·004050	$\mathbf{M}$=0·004050
	Oxygen,	0·000489	0·007824
	Nitrogen,	0·000602	0·008428
	Chlorine,	0·000627	0·022258
Liquid or solid:			
	Sulphur,	0·002044	0·065144
	Carbon, diamond,	0·001810	0·021720 etc.
μ determined by Brewster's law of polarization.			
	Antimony,	0·002545	0·30540
	Silver,	0·001262	0·13631
	Mercury,	0·001987	0·39740 etc.

Elements in combination:

Butyl-alcohol	$C_4H_{10}O$=74,	M=0·001474,	$\mathbf{M}$=0·109063
Ethyl-ether	$C_4H_{10}O$=74	0·001453	0·10757

Taking Θ as the part, and $x=C_4H_{10}$, the above-stated value of $\mathbf{M}(\Theta)$ gives

$$\mathbf{M}(C_4H_{10}=\mathbf{M}(\text{tot.})-\mathbf{M}(\text{pars})=0{\cdot}100521.$$

By means of this value he now from mercury-ethyl, $C_4H_{10}Hg$, calculates $\mathbf{M}(Hg)$=0·07598, while direct determination from vapor gave

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0·031800, and by means of Cauchy's formula for reflection from metals 0·021720, while by Brewster's formula 0·39740 was obtained. In this manner he determines the equivalent for quite a number of elements.

For easier comparison the refraction equivalents are referred to that of hydrogen as unity. These values he marks [M], hence for reduction

$$M(H) : [M(H)] = 0{\cdot}004050 : 1{\cdot}00.$$

Further he deduces from these latter values the *optical atomic numbers*, that of hydrogen being 100, by the equation

$$ZG = \frac{100}{P}[M].$$

We condense Schrauf's tables into the following, giving the values of the atomic weight P (H=1), the refraction-equivalent [M] (also for H=1) and the optical atomic number ZG (that of H equal to 100). The last two refer to the *red* rays. The metallic, solid-liquid and gaseous states are indicated respectively by *m*, *f* (fest-flüssig) and *g*.*

	P		[M]	ZG		P		[M]	ZG
Hydrogen	1	*g*	1·00	100·00	Na	22	*f*	3·68	15·96
Al	27·4	*f*	5·79	21·14	P	31	*g*	4·81	15·51
Sb	120	*m*	75·59	62·99			*f*	18·70	60·31
As	75	*g*	4·05	5·23	Hg	200	*g*	7·87	3·83
		f	12·07	16·01			*f*	18·81	9·40†
Ba	137	*f*	11·38	8·30			*m*	98·38	49·19
Be	9·4	*f*	4·01	42·66	O	16	*g*	1·97	12·25
Pb	208	*f*	27·02	12·99	S	32	*g*	3·94	12·00
		m	88·60	42·60			*f*	16·13	50·40
Bo	22	*f*	9·18	41·71	Se	79·5	*m*	29·81	37·77
Br	80	*f*	10·76	13·45	Ag	108	*f*	9·08	8·40
Ca	40	*f*	6·65	16·65			*m*	33·75	31·25
Cd	112	*f*	11·61	10·38	Si	28	*f*	8·73	31·17
Cl	35·5	*g*	5·51	15·53		?	*m*	32·45	115·00
Fe	56	*m*	33·56	51·00	N	14	*g*	2·09	14·93
F	19	*f*	1·45	7·63	Sr	87·6	*f*	8·93	10·19
I	127	*f*	19·05	15·00	Ti	56	*f*	31·67	56·55
K	39·2	*f*	4·73	12·06	Bi	210	*f*	26·90	12·80
C	12	*f*	5·01	41·75			*m*	80·82	38·49
Cu	63·4	*f*	9·60	15·15	W	184	*f*	26·66	14·49
		m	17·83	27·05	Zn	65·2	*f*	7·23	10·93
Li	7	*f*	3·36	48·00			*m*	21·01	32·22
Mg	24	*f*	7·74	32·25	Sn	118	*f*	19·70	16·70
Mo	96	*f*	48·73	50·76	Zr	44·8	*f*	19·01	42·42

From this table Schrauf deduces further that the various conditions of the same elements are optically expressed in simple multiples. Thus for S as solid we have 16·13, which is 4 times 4·03, almost identical with 3·94 for sulphur vapor. Also that allied elements are optically in the same relation of simple multiples; thus the last column gives

F 7·63 (*f*), Br 13·45 (*f*), I 15·00 (*f*); Cl 15·53, *g*.
O 12·25 *g*; S 12·00 (*g*), Se (*m*) 37·77; S (*f*) 50·40;

so also N, As, P, Sb, Br, and other groups.

Though many points are yet obscure, we nevertheless hail this investigation of Schrauf as a decided progress.—*Ber. Ak. Wien*, lii, 176–211, 1865; *Pogg. Ann.*, cxxvii, 175–176, 1866. G. H.

* The symbols in the table, although none are written with barred letters, stand for the equivalents as adopted in the new system.

† By Cauchy's formula 8·96 and 4·48.

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II. MINERALOGY AND GEOLOGY.

1. *Altitudes in British America.*—The following altitudes and localities of peaks, passes and stations in the Rocky Mountains in British America are compiled from the reports and maps of Capt. Palliser's explorations, published by Parliament, 1859–'65, and are given here for convenient reference. Some of the locations are taken from the observations published in the reports, others from the maps. When there is any discrepancy between the localities which have their latitudes and longitudes given in the earlier reports, and the maps, the latter have been followed, as they are the latest publications, and therefore may be inferred to be the more correct.

The altitudes are deduced from barometrical observations (aneroid), and the temperatures of boiling water.

	Latitude, North.	Longitude, West.	Altitude above sea.
	° ′	° ′	feet.
South Kootanie Pass,	49 10	114 55	6,030
British Kootanie Pass,	49 20	114 58	6,300
Kananaskis Pass,	50 40	115 25	5,700
Vermillion Pass,	51 12	116 10	4,903
Kicking-horse Pass,	51 24	117 25	5,210
Bow river Pass,	51 40	117	6,347
Pipe-stone river Pass,	51 40	116 30	7,200
Howe's Pass,	51 45	117 20	5,400
Otter Lake (source of the Columbia river),	50 07	116 5	3,090
Kootanie Trading Post (U. S.),	48 56	115	2,300
Fort Colville (U. S.),	48 38	118 3	1,050
Mt. Murchison,	51 47	117	13,500
Mt. Forbes,	51 45	117 36	13,400
Sullivan's Peak,	50 52	117 50	7,858
Mt. Tekarra,	52 50	118 40	
Mt. Brown,	52 28	118 25	
Mt. Hooker,	52 17	118 12	
Mt. Balfour,	51 35	117 10	
Mt. Vaux,	51 20	116 45	
Mt. Robinson,	50 52	115 27	
Mt. Head,	50 24	115	
Fort Carleton,	52 52	106 16	1,321
Fort Edmonton,	53 31	113 15	2,088
Old Bow Fort,	51 9	115 4	3,963
Rocky Mountain House,	52 40	115 10	3,195
Jasper House,	53 12	118 10	

"Kicking-horse Pass" is given here as located on the map; in the earliest report it is stated as long. 117° 20′ W., and alt. 5210 ft. (Rep. 1859, p. 38.)

Except Mt. Murchison, the heights named here are along the crest (watershed) of the Rocky Mountains; the names of other peaks were not added to this list, as no measurements are given. Mts. Brown and Hooker were stated by Douglass, many years ago, to be over 15,000 feet high, and on the map accompanying Sir Wm. Hooker's "*Flora Boreali-Americana*" (1840), Mt. Brown is stated to be 16,000 feet high, and Mt. Hooker 15,700 feet. In the first of Capt. Palliser's Reports (1859,

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p. 39) he states of Mt. Murchison that "it is a most massive mountain, which the Indians consider to be the highest of all the Rocky Mountains. I afterward measured two of its highest peaks." * * "They are respectively 15,789 and 14,431 feet above the sea." This was written, however, at Fort Edmonton in Oct. 1858, and on the maps published in 1865, the altitude is given as tabulated above, 13,400 feet, probably as the result of later computations.

In the later and fuller Journal (1863, p. 112) speaking of it, he says, "if a rough triangulation I made of what I supposed to be the same peak from the Kootanie Plain, is to be trusted, it must be 13,000 to 14,000 feet above the sea. The average altitude of the mountains is 11,000 to 12,000 feet above the sea, and I do not place much reliance on estimates of altitudes greater than that, as there is a striking appearance of uniformity in the altitude of the mountains."

In this great mountain mass in which these peaks are, between lat. 51° and 53°, and long. 116° and 119°, the report speaks much of glaciers. About Mts. Lyell and Murchison especially they are on a grand scale, and descend into some of the valleys to an altitude of 4,320 feet above the sea, and fill great valleys above that altitude. All the conditions requisite for producing glaciers of great magnitude are stated to exist.

W. H. B.

2. *On some remains of Paleozoic Insects recently discovered in Nova Scotia and New Brunswick*; by J. W. Dawson, LL.D.—Dr. Dawson has communicated to us a paper with the above title from which we cite the following facts. Mr. James Barnes of Halifax has discovered in the shale of the coal formation, Little Glace Bay, Cape Breton, a wing of a Neuropter, whose full expanse of wing when alive must have been *seven inches*. Mr. Scudder has named it *Haplophebium Barnesii*, and pronounces it an *Ephemerina*. This is the second species thus far discovered in the Nova Scotia coal formation, the only other having been found by Dr. Dawson some years since in a Sigillaria stump, at the Joggins.

The remains of the Devonian insects described are the wings of four species found by Mr. C. F. Hartt in the plant-bearing Devonian shales of St. John, New Brunswick, probably equivalents of the Hamilton or Chemung formations of New York. The species are *Platephemera antiqua* Scudder, of the *Ephemerina*; *Homothetus fossilis* Scudder, intermediate between the *Odontata* and *Sialina*; *Lithentomum Harttii* Scudder, approaching somewhat the *Hemeristina* of Illinois; *Xenoneura antiquorum* Scudder, another Neuropter, but the specimen is too imperfect to determine from it the family. Descriptions and wood-cuts of the wings by Mr. Scudder are given in the paper, which is to form part of the new edition of Dr. Dawson's Acadian Geology.

3. *A Monograph of the British Fossil Crustacea belonging to the order Merostomata*, Part I, *Pterygotus Anglicus*; by Henry Woodward, F.G.S., F.Z.S., of the British Museum. 44 pp. 4to, with 9 plates. From the publications of the Palæontographical Society, volume for 1865. London, 1866.—The Crustacean here described, from remains found in the lower Old Red Sandstone in Perthshire and Forfarshire, is one of the most remarkable fossils of the Paleozoic. As the author observes, the genus Pterygotus contains probably the largest species of the whole

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Crustacean class. Four nearly entire bodies have been found, the largest about four feet long and fifteen inches broad, but with the head wanting. The memoir of Mr. Woodward is very full in its descriptions and its synonymy and references, and its illustrations are of natural size. The memoir opens with a table giving the arrangement and nomenclature of the segments of the Crustacea with their appendages; remarks on the classification of the order Merostomata; a table showing the geological range and geographical distribution of the species of the order; and the bibliography of the subject. Mr. Woodward has also published in the Quarterly Journal of the Geological Society for February, 1867, an illustrated paper on some points in the structure of the Xiphosura, having reference to their relationship with the Eurypteridæ.

4. *Observations on the Glacial Phenomena of Labrador and Maine, with a view of the recent Invertebrate Fauna of Labrador;* by A. S. PACKARD, Jr., M.D. Mem. Boston Soc. N. H., Vol. I. Published May, 1867. 92 pages quarto, with two plates.—In this important memoir the author brings together the evidence and materials bearing upon the nature of the marine deposits of the Post-tertiary or Drift period in Eastern North America. In the first part a description is given of the physical and geological features of eastern Labrador, with an account of the glacial phenomena which the author has observed there, and a catalogue of the fossils collected in the "Leda Clay" of Labrador and New Brunswick. This is followed by an account of the Glacial and Drift action in New England, with lists of the Leda Clay fossils from the various localities which have been examined.

The author recognizes four epochs or changes in physical conditions during the Post-tertiary or Quaternary Period. First, a period of elevation above the present sea level, accompanied by intense glacial action. Second, a period of subsidence, attended by an amelioration of the climate, during which the "Leda Clays" were deposited. Third, the *Period of raised Beaches*, during which the sea level was 500 or 600 feet higher than at present, while the climate had become warmer, allowing a northward migration of animals. Fourth, the *Terrace epoch*, during which the land was again elevated, causing the drainage of extensive estuaries and bays, and the formation of terraces.

From the character of the fossils of the Leda Clays at various localities it is shown that during this period the marine animals of the coast were distributed after nearly the same plan as at present, except that the Arctic and Sub-arctic faunæ descended a little farther along the coast, while the Virginian fauna even extended north of Cape Cod, its present limit,—the fossil shells of Point Shirley, Mass., agreeing with the existing species of Long Island Sound. At that period the Bison and the Walrus lived together in Maine, which had a marine fauna resembling that now found in Labrador and Newfoundland. The evidence is entirely opposed to the theory of a Tertiary or Post-tertiary connection of the land between Europe and America, and to any interchange of species either of animals or plants,—those that are common to the two continents being regarded as circumpolar species, which have descended to a greater or less extent on each continent during the cold period, and retreated or perished, more or less completely, during the subsequent warmer period. No change of

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importance in the flow of the Gulf Stream could have occurred, as shown by the fossils of Point Shirley and Nantucket, but the arctic current swept more strongly against the coast of Maine and up the St. Lawrence river and Lake Champlain, and probably through the Bay of Fundy from the Gulf of St. Lawrence.

The second part of the paper is occupied by a Catalogue of the Marine Invertebrates of Labrador, in which a number of new species of Worms, Crustacea, and Mollusca are described. In the first part of the paper two new species of fossil shells are described from Labrador, viz., *Bela robusta* and *Fusus Labradorensis*, which, with numerous other interesting forms, are well figured. V.

5. *Exploring Expedition in the Interior Basin from Colorado west.*—The last Congress ordered an examination of a belt of territory on and near the 40th parallel of north latitude, between the meridians of 105° and 120° W., along and near the proposed route of the Pacific Rail Road. The survey is under the direction of the Secretary of War, or more immediately under Maj. Gen. A. A. Humphreys, chief of the U. S. Engineers, and Mr. Clarence King has been appointed to conduct the work, with the power to choose his own assistants. Mr. James T. Gardner is the first assistant in Topography, and Prof. James D. Hague in Geology. The party will consist of about ten scientific men, a few camp men, and a sufficient military escort for protection. The topography and geology of the country will receive the greater share of attention, but the other departments of science will not be neglected. A botanist, a zoologist, and a photographer accompany the expedition. The party sailed early in May for San Francisco, and will commence work as soon as possible at or near Pyramid Lake, and then work eastward.

The belt to be examined commences at the boundary of California, and extends entirely across Nevada and Utah, and into Colorado, to the eastern base of the Rocky Mountains. It is expected that when completed, and taken in connection with the labors of the State Geological Survey of California, and the private explorations of Prof. Whitney and Baron Richtofen in Nevada, it will furnish a geological section entirely across the great mountain system of the western part of the continent, at its widest portion, and include an examination of the most important formations producing the precious metals in North America. It is purposed to devote at least three years to the field-work.

Annexed is a list of the scientific corps as at present organized: Clarence King, chief in charge; James T. Gardner, H. Custer, and F. A. Clarke, Topographical assistants; Prof. J. D. Hague, Arnold Hague, and Samuel F. Emmons, Geological assistants; W. W. Bailey, Botanist, Robert Ridgeway, Zoologist, and T. H. O'Sullivan, Photographer.

6. *Locality of Secondary Fossils in Oregon;* by W. P. Blake, in a note to Prof. Dana, of June 1, 1867.—In my recent tour through Oregon I obtained a very interesting suite of fossils from Mr. Congdon at the Dalles, who collected or received them from Beaver creek and Crooked river south of John Day's, Oregon. There are *Trigonias*, apparently two species; a *Pholadomya*, *Ammonites*, *Fusus*, *Dentalium*, and a *Turrilites*, all of them very perfect casts of the inner and outer portions of the shell. The Turrilite indicates the Cretaceous age of the formation, and it is

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possible that the other fossils may be referred to the same era instead of the Jurassic.

7. *Exogenous leaves in the Cretaceous rocks of Iowa;* by C. A. WHITE. From a letter to one of the editors, dated Nebraska City, June 6th, 1867. —While at Red Oak Junction, the county seat of Montgomery county, Mr. Meek found in the sandstone there, which I had called in my late article in the American Journal the "Nishnabotany sandstone," a couple of specimens of exogenous leaves which he says are identical with some of those described from the Lower Cretaceous of Nebraska. This is very satisfactory, since it confirms my previously expressed opinion; the place is the most southerly point at which undoubted Cretaceous rocks have been seen in Iowa.

8. *C. A. White on Drift Phenomena in S. W. Iowa.*—To the close of the first paragraph on page 303, vol. xliii, the following sentence should be added. "Sets No. 3 [on an accompanying map not published] represent a current coinciding quite nearly with the general direction of the drainage upon the western water-shed, and sets No. 1 and No. 2 represent currents approximately coinciding with the general courses of the Missouri and Platte rivers."

9. *On new localities of Diamonds in California.*—Prof. Silliman communicated through Mr. Goodyear the following facts to the Academy of Sciences of California at the meeting on May 7th. One diamond had been found in French Corral which weighed 5·114 grains (equal to 1⅓ carats). It was symmetrical in form and slightly yellow in color from being subjected to a fire test. It was found in the deep gravel washings. The second specimen was from Forest Hill, El Dorado (Placer?) county; weight 5·673 grains, equal to nearly 1½ carats; color good, but less perfect and symmetrical than the first. The third specimen was from Fiddletown, Amador county. It is smaller and less perfect than either of the others. Since 1855 five diamonds are known to have been found at Fiddletown, none weighing much over a carat. All were found in a gray, cemented gravel, underlying a stratum of lava or compact volcanic ashes. The fourth specimen was from Cherokee Flat, Butte county, which has acquired some reputation as a diamond locality. It has been cut and set in a ring.

10. *Note upon "Partzite;"* by WM. P. BLAKE.—The silver ore from Blind Springs, Mono county, California, described by Mr. Arents as a new mineral under the name Partzite (this Jour., xliii, 362), appears to be a mechanical mixture without a definite chemical composition. It evidently results from the decomposition of the antimonial and plumbiferous silver ores in the upper portions of the veins of that region. Specimens which I obtained there last year exhibit a variety of colors, and I do not think that analyses of any two different samples would agree.

11. *Reliquiæ Aquitanicæ; being Contributions to the Archæology and Palæontology of Périgord and the adjoining provinces of Southern France;* by EDOUARD LARTET and HENRY CHRISTY. Edited by Thomas Rupert Jones, Prof. Geol., etc., Roy. Military College, Sandhurst. Part IV, March, 1867, pages 25–32, and 57–72, Plates A. XIII, XIV; B. VII–X. (London, H. Baillière; Baillière Bros., New York).—This new number of the Reliquiæ Aquitanicæ opens with a brief statement of the charac-

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teristics of the Reindeer period, and next takes up the features and geology of the valley of the Vezère. We cite the following paragraphs from Mr. Christy's observations on the Reindeer period.

"It would be easy to cite many circumstances illustrative of the resemblance between the condition and habits of the modern Esquimaux and these cave-dwellers of France at the Reindeer-period. But now comes the great question, When was the Reindeer-period in Southern France? and what is its antiquity?

"It is far easier to indicate its place in the series of observed facts in relation to ancient Man, than to assign to it any definite antiquity of years. Geologically, a wide gulf separates it from the Drift-period, though perhaps wider in the geological than in the paleontological aspect; but, on the other hand, it will seem, both from the paleontological and archæological bearings, to be of higher antiquity than the Kjökkenmöddings of Denmark and the Lacustrine Dwellings of Switzerland, and very certainly than the whole group of so called Celtic and Cromlech remains. Comparing its fauna with that of these various periods, the Reindeer-period may be placed thus:—

"In the Drift (Valley-gravels) the Mammoth, Rhinoceros, Horse, and Ox are the predominant animals, and the Reindeer appears but sparingly. In the Dordogne Caves the Reindeer predominates, associated largely with the Horse and Aurochs, and exceptionally with some remains of Mammoth, Hyena, &c.; but all traces of such domesticated animals as the Sheep, the Goat, and the Dog are wanting.

"In the Kjökkenmöddings of Denmark, though so much nearer the Subarctic regions, the Reindeer is not found, and the fauna, though more ancient than that now existing, indicates the presence of domesticated animals (Dog).

"The same may be said of the Swiss Lacustrine Dwellings: domestic animals are present; and the Reindeer is absent even from the most ancient of them, though that it was once in the neighborhood is manifested by the existence of its remains in caves (at l'Echelle) in the same district.

"In none of the Cromlechs or Sepulchres is there a trace of the Reindeer; and the fauna indicated by the remains found in them is cited as more recent than either the fauna of the Kjökkenmöddings or that of the most ancient of the lake-dwellings.

"From the archæological or industrial point of view, it may be remarked that from the Drift we have no example of Man's industry except implements of flint; and of these only the larger and coarser have been detected, though there is no reason to doubt that he had also implements for finer work than the majority of those found are fitted for.

"In the Reindeer-period, although Man had attained to a great proficiency in chipping, we have a total absence of ground or polished axes; and though he had arrived at the art of sewing, there is no trace of his having known how to spin; and in many of these caves of Dordogne there are no traces of pottery.

"In the Kjökkenmöddings pottery is not unfrequent, though ground axes are very few, but not wholly wanting, and spindle-whorls are scarce.

"In the very oldest of the lake-dwellings (those in which there is no trace of metal, as at Wangen) the majority of the axes are ground, and

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the grinding-beds are the same as those found in the Surface-period of Denmark and England. Pottery is abundant; not only spinning but weaving is presented; and there are evidences that the cultivation of wheat and other cereals had been attained to. In the Cromlechs and the Sepulchres, pottery is abundant; and the frequent occurrence of articles in bronze indicates a later time.

12. *Manual of Geology;* by the Rev. SAMUEL HAUGHTON, M.D., F.R.S., Prof. Geol. Univ. of Dublin. 2nd ed., revised and considerably enlarged. 416 pp., 12mo. London, 1866. (Longmans, Green, Reader, and Dyer.) —Prof Haughton has aimed to present in his Manual the general results of geological investigation without many of its details. He commences at once with the origin of the globe, and presents deductions as to the successive steps of progress in its inorganic material and its life, throughout the history, illustrating this progress with many diagrams. While we could not subscribe to all of the deductions, thinking them often more positive than the facts warrant, we commend the book as one that will be read with profit. But it appears to us better for the teacher, to use in connection with his other works on the subject, than for the pupil. The author takes strong ground against the hypothesis of Lamarck and Darwin.

13. *On Species of Fossil Plants from the Tertiary of Mississippi*; by LEO LESQUEREUX. 24 pp., 4to, with 10 lithogr. plates. (From the Trans. Am. Phil. Soc., vol. xiii.)—A brief account of the plants here figured and described was given in the Geological report on Mississippi (1860) of Eug. W. Hilgard, by whom the specimens were collected. 22 species are described from the Red shale, making with 10 before described from Somerville, Tennessee (this Jour., II, xxvii, 363), 32 species; and 6 from the White soft clay of nearly the same age. They pertain to what Prof. Hilgard calls the North Lignitic group. One species, the *Calamopsis Danai* Lesq., is given in Dana's Geology, from a drawing furnished the author by Prof. Lesquereux. The other species are of the genera *Sabal*, *Salisburia*, *Populus*, *Salix*, *Quercus*, *Ficus*, *Laurus*, *Cinnamomum*, *Banksia*, *Persea*, *Ceanothus*, *Sapindus*, *Rhamnus*, *Juglans*, *Magnolia*, *Asimina*, *Phyllites*. Two of the plants of the genera Rhamnus and Phyllites are referred to living species, and the whole are pronounced by Lesquereux to have close relations to Miocene species. Yet he admits a resemblance to the Cretaceous plants of the Upper Missouri, and leaves the question of age unsolved for want of more data.

Prof. Lesquereux closes his memoir with descriptions of fossil leaves from the "Upper Cretaceous" of Fort Ellsworth, Nebraska.

14. *State Geological Survey of Iowa. Preliminary notice of New Genera and Species of Fossils;* by C. A. WHITE, M.D., State Geologist, and O. H. St.John, Assistant. 4 pp., 8vo.—Professor White mentions in this sheet, the occurrence of Protozoan shells of the genus *Amphistegina* in the Coal-measures of Iowa. He also describes the following species; *Aulosteges spondyliformis*, *Waldheimia compacta*, *Beyrichia lithofactor;* and the new genus *Meekella* to include as the typical species *Orthisina Missouriensis* Swallow (*Orthisina striato-costata* Cox), together with *Orthisina Shumardiana* Swallow, *Productus eximius* Eichwald, *Streptorhynchus occidentalis* and *S. pyramidalis* Newberry.

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15. *Revue de Géologie pour les années*, 1864 et 1865, par M. DELESSE, Ingénieur en Chef des Mines, Prof. Géol., etc., et M. DE LAPPARENT, Ingénieur des Mines, Vice-Sec. Soc. Géol. de France. 279 pp., 8vo. Paris, 1866.—This annual is much like its predecessor noticed in volume xli. While not a complete review of the Geological papers of the years 1864, 1865, it contains much to interest all who would follow the progress of the Science of Geology.

III. BOTANY AND ZOOLOGY.

1. *Flora Orientalis, sive Enumeratio Plantarum in Oriente a Græcia et Egypto ad Indiæ fines hucusque observatarum;* auctore EDMOND BOISSIER. Vol. I, *Thalamiflore.* Basel and Geneva, 1867. pp. 1017, roy. 8vo.—We have just received this first volume of the flora of the Orient, with which, as is well known to botanists, Mr. Boissier has long been engaged. It is greatly needed, and will no doubt be ably and indefatigably carried on, we trust to an early completion. It connects the proper flora of Europe with that of Africa on the one hand, and of India and Siberia on the other; and covers the most interesting of all lands, Palestine and all Syria, Mesopotamia and Persia, Egypt and Greece. The preface briefly sketches the general characters of these regions, the botany of which is thus combined, notes the explorers who have made collections in any of them, from Rauwolf, Tournefort, and Wheeler down to the present time, indicates the districts in which he has himself botanized, and enumerates generally the sources of the various materials available for this work. He explains the plan of the publication, and the principles by which he is guided. He announces his conviction that species are direct creations as such, and fixed in character, variable more or less, but only within certain limits. To specific names he prefers to append the original authority for that name under whatever genus it may have fallen: e. g. "*Matthiola tristis* L. sub Cheirantho,"—although Linnæus, who had both genera, referred this species to *Cheiranthus.* In their orthography, he continues to write geographical adjective names with a capital initial, after the manner of DeCandolle, e. g., *Matthiola Arabica*, an usage which has never been universal, and from which in general there is a tendency to recede; while on the other hand, he writes proper substantive specific names with a small initial, e. g. *Ranunculus flammula*,—in which perhaps he stands nearly alone. Neither the species nor the genera are numbered. The name, specific character, and synonymy form one paragraph, the habitat another, in smaller type, descriptive notes or observations (when there are any) a third, and the geographical distribution, when wider than the limits of the work, is indicated in a fourth paragraph. Varieties also occupy separate paragraphs. The whole arrangement is very clear and convenient; but the type is so large and the page so open that the work will be more bulky than we should have thought expedient. Of its substantial excellence and conscientious accuracy there can be no doubt. A. G.

2. *Catalogue des Végétaux Ligneux du Canada, pour servir a l'Intelligence des Collections de bois économiques envoyées a l'Exposition Universelle de Paris*, 1867; par l'Abbé OVIDE BRUNET, etc. Quebec. 8vo

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pamph., pp. 64.—Professor Brunet has brought out this convenient catalogue for the special purpose mentioned in the title; but it ought to be otherwise useful. He has not numbered the species, nor given their enumeration, so that we cannot without counting ascertain how many woody plants Canada can boast of. Plants so little woody as *Clematis Virginiana*, and even *Chiogenes*, and *Helianthemum Canadense* are included. But there is no mention of *Smilax*, nor of *Juniperus Sabina*, nor of the Red Spruce, nor Gray Oak, both probably mere varieties of other species, but worthy of examination by Canadian botanists. There are, also, two distinct kinds of Mountain Ash growing in the vicinity of Quebec, which Canadian botanists should notice.

Histoire des Picea qui se rencontrent dans les limites du Canada, is a smaller pamphlet by the same author, issued in 1866, with a plate of the two species, *P. alba* and *nigra*—the White and Black Spruce, and two photograph views of trees of the former. The glaucous-leaved variety of the Black Spruce, the common and almost the sole form of the species in Eastern New England, is named by Prof. Brunet, var. *grisea;* it is popularly called in Canada *Epinette Blanche*, or *Gray Spruce.* Spruce beer (made from Black Spruce), it appears, is an early invention. Prof. Brunet copies from Duhamel a curious account of the manner of making it more than a hundred years ago. A. G.

3. *Report of Proceedings of the International Horticultural Exhibition and Botanical Congress held in London, May* 22–31, 1866.—We reprinted at the time the masterly address of the President of this Botanical Congress, A. DeCandolle, and notices of most of the botanical papers read at the sessions, gathered from the abstracts published in the Gardeners' Chronicle. The Honorary Secretaries, Messrs. Moore, Hogg, and Masters, have how issued an official account of the whole proceedings, in a handsome royal 8vo volume of 428 pages, with plates, maps, &c. The volume is replete with interest, both horticultural and botanical. One of the most interesting articles is that of Dr. Masters on Double Flowers, which, did time and space allow, we should have been glad to present to our readers, in full or in abstract. A. G.

4. *Collections of Dried Plants of California* are often asked for, and may now be supplied. Mr. Bolander, who has formerly supplied some Grasses, &c., in this way, has now made up, from his recent collections in California, a dozen sets of beautiful and complete specimens of about 350 species of choice Californian plants; of which over one-third are *Cyperaceæ* (chiefly *Carex*) and *Gramineæ*, and more than a quarter *Compositæ.* The specimens will be named, according to the numbers. Sets can be had for $12 in currency per hundred, by making early application to Mr. Horace Mann, at Harvard University Herbarium, Cambridge. A. G.

5. *Growth of Lycoperdon giganteum;* by F. Moigno, in the Chem. News, Apr. 19, 1867.—The unexpected observation of the *Lycoperdon giganteum* has led M. Ernest Baudrimont to some very interesting conclusions. Fourteen days after its apparition at the surface of the ground it had acquired a considerable size. Plucked on September 17, 1866, when it commenced to decrease visibly, it was nearly of a regular spheroidal form, with a very short peduncle of a very beautiful white color, dull, and

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slightly rosy; the skin was distended, and elastic under the pressure of the finger; its circumference measured 1m. 4c. on its greatest diameter, the weight being 3 kilo. 500 grams. When detached circularly by means of a sharp instrument, a great quantity of turbid liquid was disengaged of a greenish-yellow color. It was placed immediately in a baking-oven, where it remained twenty days. Taken out completely dried, it weighed 305 grams, thus showing that before desiccation it contained 91·28 per cent of water. Analysis has proved that nitrogen gas represented alone 8·96 per cent of the weight of the dried fungus, or 0·78 per cent of the weight of it in its normal state. If we suppose all this nitrogen to have been in the state of albumen, a substance which contains 17·70 per cent of nitrogen and 53 per cent of carbon, the total mass of lycoperdon (305 grams) contains 174·063 grams of carbon; we have even 142 grams by adding the carbon contained in the non-nitrogenized substances, its cellulose, &c. This being ascertained, we have 142 grams of carbon representing 520·66 grams, or 265 liters of carbonic acid, and thence 530,000 liters of air. It is from this enormous volume of air, which is about equal to a cube of 8 meters linear edge each way, that the fungus in question must have drawn, without losing a single trace, and, if we may so term it, with mathematical precision, the 142 grams of carbon necessary for its development of fourteen days. This is at the rate of, per day of twenty four hours, 10·15 grams of carbon, 18·9 liters of carbonic acid gas, and 37,800 liters of air. At 86,400 seconds per day, it is upon nearly half a liter of air that the plant must have operated per second to effect the total extraction of the carbonic acid gas which was in it. By what means can we estimate the prodigious activity that this inferior plant could develop to be able to take in fourteen days all the carbonic acid belonging to 530,000 liters of air? How astonishing, then, must be the delicacy of the absorptive organs which seize on its flight an elastic fluid—if we may so call it—intangible, disseminated in such an enormous mass, continually moving with great rapidity! But this is not all. The mean circumference of the fungus was 0·990 m.; the radius, 0·157 m.; its volume more than sixteen millions of cubic millimeters; and its mass formed of cellules 1 millimeter long at most, and the $\frac{1}{300}$th of a millimeter in thickness, between which are placed the reproductive spores. The total number of the cellules exceeds fourteen billions (14,589,140,400); and since the development lasted fourteen days, a million of cellules had to be produced every four hours—twelve thousand cellules per second! Just let one stroke of the pendulum, and then another, be heard, and conceive, if you can, that in that space of time the fungus constructed 12,000 cellules, besides (as the spores are a hundred times at least more numerous than the cellules) 1,200,000 spores, without any sensible shock or any hurried interior derangement capable of disturbing the mysterious equilibrium that reigns through all the parts of this living body. How great, then, is the prodigious energy which animates the material substance, and which can accommodate itself instantaneously to the exigencies of life!

6. *On the Parallelism between the different stages of Life in the Individual and those in the entire Group of the Molluscous Order Tetrabranchiata;* by ALPHEUS HYATT. (From the Memoirs of the Boston Society of Natural History, vol. I.)—In this paper the remarkable changes, which

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take place in the advanced period of life of an Ammonite by a process of degeneration or degradation of its structural character, are shown to have a singular analogy with the gradual decline in the characters of the genera and species just previous to the extinction of the order in geological times. The analogy of the process of decline in old age with that of development during the young state is also discussed, as well as the correspondence of the latter with the first appearance and gradual increase of the order in its geological history. V.

7. *Notes on the Radiata in the Museum of Yale College, with Descriptions of New Genera and Species;* by A. E. VERRILL. (From the Transactions of the Connecticut Academy of Arts and Sciences, Vol. I, Part II, 1867.)—*No.* 1. *Descriptions of New Starfishes from New Zealand.* Published March, 1867.—In this paper four new species of starfishes are described, two of which represent new genera, viz., *Cœlasterias australis*, *Coscinasterias muricata*, *Asterina regularis*, and *Astropecten Edwardsii.* The genus *Cœlasterias* is allied to *Asterias*, having four rows of suckers, but is multiradiate, with a large disk and large swollen arms. It has the aspect of *Solaster. Coscinasterias* is an allied genus, also with numerous rays, which are long and slender, arising from a comparatively small disk.

No. 2. *Notes on the Echinoderms of Panama and West Coast of America, with Descriptions of New Genera and Species.* Published, in part, March, 1867.* This paper embraces a complete review of all the Echinoderms, except Holothurians, contained in the Yale College Museum, from the west coast of Central and South America. Most of the materials are derived from the collections of Mr. F. H. Bradley, who has spent the past year on that coast. Sixty-eight species are enumerated, nearly all of which are described in detail, whether new or previously known. Twenty-two new species are included in this paper, together with four new genera. Among the more interesting new species are the following: *Astrophyton Panamense*, *Ophiura Daniana*, *Hemipholis gracilis*, *Ophiothela mirabilis* (new genus,) *Astropecten fragilis*, *A. Peruviana*, *Asterina modesta*, *Oreaster occidentalis*, *Mithrodia Bradleyi*, *Echinodiadema coronata* (new genus), *Astropyga venusta*, *Euryechinus imbecilis* (=E. gibbosus Val. ?), *Psammechinus pictus*, *Boletia viridis*, *Mellita Pacifica*, *Astroclypus Manni* (new genus), *Metalia nobilis*, *Brissus obesus.*

The name, *Ophiothela*, is proposed for peculiar, small, six-rayed Ophiurians allied to *Ophiothrix*, of which this group is made a sub-genus. *Echinodiadema* is allied to *Diadema* but has a spinose buccal membrane, trigeminate pores, and hollow spines. *Astroclypus* is allied to *Encope* and *Lobophora.* It differs from the first in having but four ovarial openings and in lacking the posterior perforation, and from *Lobophora* in having five ambulacral perforations, the position of the anus, etc.

Several changes in the nomenclature of known species are introduced, some of which are as follows: *Oreaster armatus* M. and Tr. is made a separate genus under Gray's subgeneric name, *Nidorellia; Echinocida-*

* The first part of this article embracing the *Ophiuroidea* and *Asteroidea* was printed and distributed in March and April; the remaining signatures, including the *Echinoidea*, etc., were not issued until June.

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ris incisa A. Ag. (*E. longispina* Lutk.) is referred to *E. stellata* Ag.; *Boletia rosea* A. Ag. is referred to *Lytechinus*; *Encope tetrapora* Ag. (*non* Gm.) is redescribed under the new name, *E. occidentalis*; *Kleinia nigra* A. Ag. is referred to *Meoma* Gray; *Metalia* (Gray's subgenus of *Brissus*) is made identical with *Xanthobrissus* A. Ag. Four species of *Heliaster* are recognized.

The last part of the paper contains a discussion of the Geographical Distribution of the West Coast Echinoderms, with comparative lists of all the known species of various localities, and also a list of the West Indian and Aspinwall species for comparison with those of Panama.

8. *Remarkable Instances of Crustacean Parasitism*; by A. E. VERRILL.—In a collection of about ninety specimens of a small sea-urchin (*Eurycchinus imbecillis* Verrill) from the coast of Peru, not one could be found in which the anal area and surrounding parts of the upper side of the shell were not more or less irregularly distorted, or imperfect. An examination of the interior showed that in each specimen a crab (*Fabia Chilensis* Dana), allied to the common crab of the oyster (*Pinnotheres ostreum*), had effected a lodgment in the upper part of the intestine, which had thereby been greatly distended in the form of a membranous cyst, attached to one side of the shell, and extending around to the lower surface near the mouth. The shell is usually swollen on the side over the cyst, and the anal area is depressed and distorted, with a large open orifice passing obliquely into the cyst, out of which the crab may thrust its legs at pleasure; but is apparently unable, when full grown, to come entirely out. All the specimens examined in the cyst were females, carrying eggs, but a very small crab found clinging among the spines appears to be the male. The crab probably effects an entrance into the intestine through the anus while quite young, and, by its presence and growth in that position, causes the gradual distortion of the shell and formation of the cyst. In Prof. Dana's Report on the Crustacea of the U. S. Expl. Expedition this crab is described as from Valparaiso, from an Echinus, but no special notice of its mode of occurrence and remarkable frequency appears to have been published.*

Another peculiar mode of parasitism I have observed in a singular crustacean (*Hapalocarcinus marsupialis* Stimpson†) from the Sandwich Islands. This creature lodges itself among the slender branches of a coral (*Pocillipora cæspitosa* Dana) and causes, probably by its incessant motions, the branches to grow up and surround it on both sides by flat expansions of coral, terminating in digitations, which often interlock above, leaving openings between them suitable for the uses of the parasite, but usually too small to allow of egress. Most specimens of the corals of this species sustain one or more, and often numerous, examples of these curious enlarged bulbs among the branches. The habits were unknown to Dr. Stimpson, when he described his specimens, which had dropped from among recently collected corals.

9. *On the external characters of the Young of the Central American Tapir* (*Elasmognathus Bairdii* Gill); by A. E. VERRILL.—This remarkable animal has hitherto been known only by its skull, and a skeleton, not

* *Pinnaxodis hirtipes* Heller, recently described fram Ecuador and found in an *Echinus*, is probably the same species.

† Proceedings Boston Soc. Nat. Hist., vi, 412.

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entirely complete, belonging to the Smithsonian Institution. The Museum of Yale College has recently been so fortunate as to receive from J. H. Sternberg, Esq., a specimen of the young animal, preserved entire in alcohol. This individual is a female, and is supposed by Mr. Sternberg to have been about three months old in April. He states that its weight is not more than that of the head of the adult, one head that he formerly examined weighing 82 pounds.

Its entire length is 31 inches; nose to occiput 11; nose to eye 4·25; nose to incisor teeth 1·5; eye to ear 3·2; lower jaw 6·5; length of ear 3·5; breadth 2·5; tail from vent, not including hair, 2. The legs are short and stout. The tail small and inconspicuous. The head, viewed from the side, is elongated oval; from above elongated triangular, the sides nearly straight, the nose truncated. In advance of and above the eyes, the sides of the nose are compressed and concave, with a slight depression on its ridge. Beyond this the snout is enlarged, and convex both on the sides and above; the tip papillose and slightly decurved, which gives it a truncated appearance. The nostrils are large, oval, placed obliquely at the end of the nose, about half an inch long, the inner angles separated about a quarter inch, the margins thickened. The nose itself is quite flexible and, apparently, capable of extension. The ears are large and prominent, broad oval, rounded at the end. The hair is rather fine and soft, about an inch long on the body, and half as long on the head, where it is not so thick.

The general color is bright reddish-brown, the head darker above. The lips and end of the nose, bordering the naked, black tip, are white. Five interrupted narrow white stripes pass along each side of the nose, the upper one extending over and beyond the eye. The cheeks have several larger patches of whitish, one of which is under the eye; a larger white spot is on the throat. The ears are dark brown, lighter at the outer base, the tips, and several unequal spots on the outside, white. The back and sides are marked by longitudinal rows of yellowish-white patches, which partially blend into continuous stripes on the sides. There are in all about ten of these stripes. The under side of the body is uniform yellowish gray. The legs are darker brown than the body, and marked by numerous transverse bands and spots of white.

IV. ASTRONOMY.

1. *Prof. Adams upon the orbit of the November meteors.*—It was shown some time ago (this Journal, II, xxxviii, 57) that the periodic time of the November meteors must be one of five accurately determined periods. These five periods were 180·0 days, 185·4 days, 354·6 days, 376·6 days, and 33·25 years. The longitude of the node was also shown to increase with respect to the ecliptic 1″·711 in a year, which is equivalent to a procession with respect to the fixed stars of 29′ in a cycle of 33·25 years. It was also suggested that by computing the theoretical secular motion of the node for each one of the five possible orbits, and by comparing it with the observed motion we have an apparently simple means of deciding which of the five orbits is the true one.

Soon after the remarkable display of the meteors in November of last year, Prof. Adams undertook the examination of this question. Taking

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first the orbit corresponding to a periodic time of 354·6 days, he found that the action of Jupiter produces an annual increase of the longitude of the node equal to 6″, and that of Venus an annual increase equal to 5″. The action of the earth was not so easily computed, owing to the intersection of the two orbits. An approximate solution applicable to this case showed, however, an annual increase of the longitude of the node of about 10″ due to this cause. The whole computed procession of the node was therefore about 21″ a year, or 12′ in the cycle of 33·25 years. The periodic time, 376·6 days, gives a result not widely different from the above, while in the two smaller orbits there would be a much smaller motion. Hence these four orbits, out of the five possible ones, are incompatible with the observed motion of the node.

Computing then the effect of the perturbing action of the planets upon the group, supposing it to have a periodic time of 33·25 years, Prof. Adams found that Jupiter increases the longitude of the node 20′ in one revolution, that Saturn increases it 7′, and Uranus increases it 1′. The other planets produce hardly any sensible effects, so that the entire calculated increase of the longitude of the node in the period of 33·25 years is about 28′. The observed increase during the same time is 29′. This remarkable accordance between the results of theory and observation appears to leave no doubt as to the correctness of the period of 33·25 years.

2. *Connection of Comets with Meteors.*—The remarkable relation between the Comets III 1862 and I 1866 and the August and November meteors naturally suggests a possible connection between other comets and other real or suspected meteor-showers.

Dr. Weiss of Vienna,* using a list of dates of star showers obtained from Humboldt, Quetelet, and Heis (overlooking the necessity of referring the showers to a fixed equinox), has computed the radius vectors of various comets at their two nodes, and finds the following coincidences. In the last column R − r is the earth's radius vector at the node, minus that of the comet. We give the whole table notwithstanding the fact that some of the showers are uncertain. The two dates in April belong to the same shower.

Date of shower.	Nodal passage.	Comet.	Node.	R - r.	
Jan. 1–4,	Jan. 3	II. 1792	♉	−0·073	
" "	" 4	IV. 1860	☊	+0·025	
Apr. 4–11,	Apr. 13	837	☊	−0·021	Very uncertain orbit.
" 20–24,	" 20	I. 1861	♉	0·002	
July 27–29,	July 27	II. 1737	♉	+0·005	
Sept. 18–25,	Sept. 17	I. 1790	♉	−0·054	Uncertain orbit.
" "	" 17	I. 1763	☊	−0·016	
Oct. 19–26,	Oct. 19	1779	☊	+0·024	
" "	" 20	1739	♉	−0·078	
" "	" 21	1097	♉	+0·056	
" "	" 24	1366	♉	−0·054	
Nov. 28,	Nov. 28	Biela's	♉	−0·018	
Dec. 6–9,	Dec. 9	IV. 1819	☊	+0·085	

The Comet II 1852, as well as III 1862, crosses the path of the earth on the 10th of August. Dr. Weiss suggests this as a cause of the want of definiteness of the August radiant, and of the duration of the shower.

* Astron. Nachr., No. 1632.

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Prof. D'Arrest shows* that the meteors of the 6–7th of December have a radiant which is well represented by supposing them to have been formerly connected with Biela's comet. The longitude of the earth at the time (Dec. 6–7th) is 74°—75°, while the longitude of the node of Biela's comet from 1772 to 1832 was from 73° to 68°.

De Galle also shows† that the radiant for April 19–20th, which was given by Mr. Herrick as near α Lyræ in 1839, and which was found by Mr. Alex. S. Herschel to be at that point in 1864, differs only 7° from what would result from an orbit like that of comet I. 1861. This is within the possible error of observation.

The comet I. 1861 was discovered by Mr. A. E. Thatcher at Mr. Rutherfurd's observatory in New York City. At its brightest, it was equal to a star of the 2d or 3d magnitude.

Mr. Schiaparelli argues‡ that the mass of Uranus is so small that it is impossible for it to have turned the group of November meteors out of an orbit differing much from that described at present, without having at the same time entirely scattered the group. The perturbing body, which caused the change from a parabolic or a long elliptic orbit, is then either Jupiter or Saturn. It seems, therefore, to be necessary to reject the hypothesis of LeVerrier, that the great perturbation of the stream was due to Uranus and occurred in the year 126 of the Christian era.

Mr. Faye has presented to the Paris Academy of Sciences a hypothesis which connects the shooting stars, the zodiacal light, the rays of the corona seen in a solar eclipse, and the resisting medium which is believed to shorten the time of Encke's Comet, with the matter which is seen to flow from the nuclei of comets, forming their comas and tails. H. A. N.

3. *Observations of Shooting Stars, May 12th*, 1867.—It was thought that if the period of the November meteors was 354·6 days, we should probably meet a few straggling members of the group at the ascending node of their orbit, that is, on the 12th of May, 1867. The denser portion of the group of meteors would in six months, perhaps, have passed beyond the node. But if no stray members were to be seen *going toward Leo*, the evidence, though negative, would confirm the 33¼ year period. Accordingly, at Chicago, at Williamstown, at Olivet, and at New Haven, a watch was kept on that morning.

At Chicago, Mr. Francis Bradley, between a quarter before two and half past three o'clock saw but nine shooting stars, of which only two reminded him of the November meteors. Even the paths of these, as described in his letter, could not be regarded as going directly toward Leo.

At Williamstown, Mass., Mr. Leavitt saw 18 meteors between $1^h\ 50^m$ and $3^h\ 40^m$, five of which were noticeable as leaving the white train characteristic of November meteors. The paths of two of these are given in his letter. If produced they would pass a moderate distance from the Sickle.

At Olivet, Mich., Prof. Hewitt and Mr. Gaines, between $1^h\ 45^m$ and $3^h\ 15^m$, saw 28 shooting stars. There seemed to be a tendency to radiate from a region north of Aquarius, between that constellation and Pegasus.

* Astron. Nachr., No. 1633. † Ibid, No. 1635.

‡ Les Mondes, xiii, 501, March 28, 1867.

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On the same morning, in the hour between 2^h and 3^h, A. M., Mr. A. Van Name, Mr. O. Harger, and the writer, saw at New Haven 34 meteors, most of them small ones. Only three or four of these were regarded as going toward Leo. These did not present in their physical appearance resemblances to the November meteors.

The result of the whole of the observations on this evening was to confirm the $33\frac{1}{4}$ year period. Since that time the remarkable results of Prof. Adams's computations have been received, which leave no longer the possibility of a doubt as to the true period. H. A. N.

4. *Elements of Comet* III, 1862.—Dr. OPPOLZER of Vienna, has given in the Astronomische Nachrichten, No. 1638, the following corrected elements of the Comet III, 1862, which is connected with the August group of meteors.

		Osculation: 1862, Aug. 23·0	
T	=	Aug. 22·947139 Berlin m. t.	
π	=	290° 12′ 47″·84	mean equinox 1862·0
☊	=	137 27 10 ·02	
i	=	113 34 12 ·24	
log q	=	9·9834650	
e	=	0·9607588	
log a	=	1·3897227	
per. time	=	121·502 years.	

Schiaparelli suggests a period of 108 years for the August meteors, the suggestion being based upon the following dates of star showers, from Quetelet's and Biot's catalogues; viz., 830, 833, 835, 841, 925, 926, 933, 1029, 1243, 1451, 1779, 1784, 1789.

A period of 108 years is however regarded by Dr. Oppolzer as incompatible with the observations, unless by allowances of errors which are altogether improbable. Planetary perturbations play a small part, it is believed, in the theory of this stream, as an exact determination of its period will doubtless show that it does not come near any planet except the earth.

5. *Comet* II, 1867.—A faint comet was discovered by Mr. Tempel at Marseilles on the third of April, 1867.

6. *Division of Biela's Comet.*—Prof. Bruhns of Leipsic, notices the fact* that at the time of the discovery of the division of Biela's comet it was crossing the path of the November stream. It seems hardly possible, however, that the density of the stream could have been sufficient, at that time and place, to have accomplished the separation.

7. *The Moon-crater "Linné."*—In the center of the bright spot which covers the former crater "Linné," there appears a minute black point, indicating a crater of about 600 yards diameter. The original crater appears to have been a deep one, and about 10,000 yards in diameter. This small crater was so plainly visible as to have been noticed (independently as it would seem) by Dr. Schmidt at Athens, by P. Secchi at Rome, and by Prof. Lyman at New Haven. It was detected here three days after the sun had risen over the horizon of "Linné," and when the sun was therefore 30° or 35° high upon it. These observations show that any change which has taken place is not in the nature of a development

* Astron. Nachr., No. 1631.

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of a cloud, but imply rather that the old crater has been filled up by an eruption from the small one now visible.

According to Prof. Respighi of Rome, the western margin of the small crater in "Linné" is higher than the eastern, and was even visible as a bright point just before the sun rose upon the crater. He thinks that the historical evidence is not sufficient, however, to prove beyond doubt that a change has taken place.

Dr. Schmidt states that numerous and careful observations made during the four lunations, both in the waxing and in the waning moon, prove that "Linné" under no direction of the sun's light can now be seen as a normal crater.

Mr. Flammarion at Paris, observing carefully the place of "Linné" immediately after the rising of the sun upon it, could not detect the least shadow either within or without the position of the former crater. The fact that the height of the mountain was never given by the earlier observers he adduces as proof that it did not then have great altitude above the surrounding plain. Watching the place of "Linné" before the sun rose upon it he saw no light.

8. *Der Meteorsteinfall am 9 Juni*, 1866, *bei Knyahinya* (*zweiter Bericht*); von W. Ritter v. Haidinger. 48 pp., 8vo, with 3 plates; from the Berichte Akad. Wien., liv, Oct. 1866.—Haidinger here gives additional testimony with regard to the meteorite which was seen to fall a year since, in Hungary, 25 geographical miles N.N.E. of Unghvár, and 6 N.N.E. of Nagy Berezna. The remarkable facts and appearance attending the movement and fall are fully described from communications by many eye-witnesses, and illustrated with colored figures. The whole weight of the pieces that fell was about 900 pounds, and one piece is stated to have a weight of 550 pounds (Austrian). The memoir gives the exact geographical positions of the principal observers and discusses the movements of the meteor.

Haidinger, whose contributions to the department of meteorites have far exceeded in number and value all those of other contributors, and who has now become a veteran among philosophers, observes in a note accompanying the copy of the above mentioned memoir, that, while thus laboring for the progress of the science, he has never made any collections of meteorites for himself; and he now appeals frankly to the generosity of those who have made such collections for "such one or another fragment of meteorites or meteoric irons, as they may have at hand for disposal." He adds "I ask this as a free gift, to be received by me without any substantial retribution or equivalent, excepting the most cordial thanks for such great proofs of a liberal heart." Such gifts as he thus solicits are due to the liberal-hearted Haidinger. We rejoice to learn that he has been "honorably placed in retirement" by the Emperor as director of the I. R. Geological Institute of the Austrian Empire.

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V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Earthquake in Kansas.* (1.) Notice of the earthquake by WM. H. R. LYKINS, from a letter to the editors, dated Lawrence, Kansas, April 25, 1867.—Yesterday the 24th of April, at 3 P. M., this locality was visited by an earthquake quite severe for this latitude. It was accompanied by the usual loud rumbling noise similar to that caused by the passing of half a dozen heavy omnibuses. The earth did not seem to rise or rock, but to tremble or vibrate. No dust was raised nor was there any unusual atmospheric disturbance perceptible; the weather being clear and cool. Doors and windows were violently shaken, type thrown down in printing offices, bottles shaken off druggists' shelves, plaster broken off, and in some instances walls slightly cracked. Persons out of doors did not feel any movement of the ground, but could see the buildings tremble. A butcher informed me his spring balance was drawn down a pound and a half by the shock. It commenced with a slight trembling, gradually increasing to its maximum and then gradually dying away; lasting, as near as I could judge, about thirty seconds, though some estimate its duration at one and a half minutes. Some professed to have felt three distinct shocks, but the majority described it as a gradually increasing and decreasing vibration. The same shock was felt simultaneously one hundred miles west and north of us; from places farther than this we have no information.

(2.) Notice of the earthquake by Prof. WM. G. WILLIAMS, from a letter to the editors, dated Marysville, Marshall County, Kansas, April 25th, 1867.—At two o'clock and thirty minutes yesterday afternoon the shock of an earthquake was felt probably in every house and place of business in and near town. It was accompanied by the usual rumbling sound, and lasted a time variously estimated from one to three minutes.

No serious injury was done to persons, or property, beyond a temporary alarm on the part of a few. In stores, bottles and packages were made to rattle and in some cases were shaken from the shelves and broken. Windows, doors, shutters, stove-pipes and all loose or hanging articles, rattled, waved, or swung back and forth fearfully.

In several instances persons in the second stories of stores and houses, hearing the noise, and seeing and feeling the unwonted motions, ran down to stop the supposed disorder and tumult below, while those below ran up to stop that above. One lady knowing it to be an earthquake seized her infant child and hastened down stairs with a view to get out of doors for safety. A gentleman fishing in Spring Creek near town was leaning against a tree, feeling it shake and looking up, he saw it and other trees trembling and moving as if agitated by wind, although no breath of air was stirring. With my assistant teacher and some seventy scholars I was in the second story of our High School edifice. It is of stone and high pitched. The whole structure, desks, stove-pipes and other furniture were much shaken. The rumbling noises below much resembled those of heavy trunks on plank floors. I have had no opportunity to learn how extensively the shock was felt.

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2. *On former changes in the Aral Sea;* by H. C. RAWLINSON, (from Proc. Roy. Geogr. Soc., March 11, 1867.)—There were certain points connected with the rivers Oxus and Jaxartes which he proposed to bring prominently before the meeting. They referred to a physical phenomenon which he believed was without parallel in the rest of the world, being, indeed, neither more nor less than the drying up at certain periods of history of the Sea of Aral, and its consequent disappearance from the map of Asia. The Aral, in terrestrial geography, might be compared with one of the variable stars in astronomy. As there were stars varying from the first to the fifth magnitude, so the Aral was at times a great inland sea 300 or 400 miles in length, at other times a mere reedy marsh, and even, occasionally, a hard desert land, so that travellers actually passed across it without being aware that they were travelling over the bed of a sea. Humboldt had devoted 200 pages of his famous work 'Asie Centrale' to the discussion of the geography of the Aral and the Caspian, and he had established beyond dispute that the Oxus had a variable course, sometimes falling into one sea and sometimes into the other; but he had not ventured to assert that the Aral ever disappeared altogether. Nevertheless, he (the Chairman) maintained that we had direct evidence of the fact in modern times, and he thought we had a right to assume its occurrence in ancient times.

The argument was briefly as follows: In all classical antiquity, from the earliest date, say from 600 years B.C. to 500 or 600 years after Christ —the Sea of Aral was utterly unknown in geography. There was not one single authority—Greek, Latin, or native Persian—who mentioned it. The two great rivers, the Oxus and the Jaxartes, which, by their contributions now form that sea, were described by all authors as falling into the Caspian. It must be remembered, too, that Alexander the Great conducted an army into that part of Asia, and employed officers for the express purpose of ascertaining the geographical configuration of the neighboring countries. He sent his troops on an expedition along the shores of the Caspian, while he in person crossed the Oxus, and reached the banks of the Jaxartes. Hence he must have possessed accurate information as to those localities, and yet the account which his officers brought back to Greece was that both the rivers fell into the Caspian. This statement, indeed, was adhered to throughout antiquity, and a practical proof was given of its truth in the notice of the line of commerce which supplied Europe with the products of Asia. This commercial route was described as starting from the foot of the Indian Caucasus, following the Oxus down to the Caspian, ascending the Kur or Cyrus, and descending the Phasis into the Black Sea, and thence crossing into Europe. We had thus direct evidence, as it seemed, that in the days when this route was followed and described, the Oxus must have fallen into the Caspian.

The Chairman went on to say, that as the present Sea of Aral filled an inconsiderable depression in the table-land of Central Asia, having no springs, and being entirely dependent for its supply on the two great rivers already mentioned, so it followed that if those rivers at any time were diverted from the Aral, the sea would necessarily become desiccated in a very few years, and the bed of it would revert to its original condition of a mere depression in the desert. The levels were a very important element in considering this question. That of the Aral was 117 feet

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above the level of the Caspian, and 33 feet above the Black Sea, the Caspian itself being 84 feet below the Black Sea; so that if a communication were formed between the Aral and the Caspian, the Aral would naturally drain off into the lower basin. To proceed, however, with the argument. If, in the times of classic antiquity, there was a unanimity of evidence that the Oxus and Jaxartes flowed into the Caspian, so, from the beginning of the Mohammedan era, say from the year 600 to about 1300, or for a period of seven hundred years, there was an equal unanimity exactly the other way. During this period the Arabs and their political successors were in possession of the country. They were a literary and scientific people, and wrote numerous works on geography. They possessed the means of ascertaining full topographical details, and they invariably represented the two rivers as falling into the Sea of Aral, or the Lake of Kharesm, as it was then usually called. The only reasonable inference then seemed to be, that between the years 500 and 600 the course of the two rivers, owing to some natural disturbance, must have changed, and that, instead of continuing to fall into the Caspian, they became diverted into the sea of Aral, themselves, in fact forming that sea. Now came the most curious part of the question. From about the year A. D. 1300 to 1500, that is, for about 200 years, Europeans possessed means of becoming acquainted with the geography of Central Asia which had never been equalled up to the present day; for there were at that time frequent missions sent from the courts of Europe to Mongolia in Central Asia, and the ambassadors so employed had for the most part preserved records of their journeys. Colonel Yule, an associate of the Geographical Society, had recently brought a general summary of those records before the notice of the public in a most interesting work ('Cathay and the Way Thither'), of which he (the Chairman) could not speak too highly, and which he could not too strongly recommend to the notice of all lovers of geographical science. Colonel Yule's book contained records of many travels across Central Asia during the 13th and 14th centuries, and in not one of those records was the Aral mentioned, although the route of the travellers lay in most cases exactly across it. One of the authors in question, named Pegoletti, gave all the details of the commercial route at that time, which conducted from the Black Sea to China, and along which merchants conveyed the luxuries of Europe, and returned with the tea and silk of China. There were, indeed, detailed notices of the route in question, not only in the itineraries of Pegoletti, but in the maps which were constructed from memoranda furnished by travellers between the 13th and 16th centuries. One of these was called the Catalan Map; another was a map preserved in the Palatino Library at Florence; another was the Borgian Map, and the most famous of all was the Venetian map of Saint Mauro; and in none of these was the Aral noticed. The travellers came in the first instance from the Volga to Sarachak, on the eastern shore of the Caspian; and from thence they passed to Otrar, on the Jaxartes, the route lying across the bed of the Aral, which, nevertheless, in no single instance was either mentioned in the itineraries or laid down in the maps. On these negative grounds alone he should consider it quite certain that at that time the Aral did not exist; but we had fortunately positive evidence to confirm that conclusion.

Probably some of those present had heard of a very famous man called

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Yar Mahomed Khan, who was chief of Herat during the period of the Afghan war about twenty-five years ago. This person had sent to him (the Chairman) during the war, as a token of friendship, a Persian manuscript, which seemed to be of very great value on account of its rarity. It was a work written by an officer of the famous ruler of Herat, Shah Rukh Sultan, and contained, amongst other matters, a geographical account of the province of Khorassan about the year 1418. The writer seemed to have been a minister of the country, and evidently knew every village and stream in the province. He (the Chairman) had made three extracts from the manuscript, which he considered to be of the utmost importance, as they recorded a physical phenomenon, namely, the desiccation of the Aral, which he believed had never up to the present time been brought to the notice of the geographers of Europe, although, as before stated, the great Humboldt had devoted no fewer than 200 pages of his standard work to the discussion of this subject. In describing the lakes of Asia the writer came in regular order to the Aral, which was called the Lake of Kharesm, and he said, "In all the ancient books the Lake of Kharesm is described as the receptacle of the waters of the Oxus, but at the present date, which is A. H. 820 (A. D. 1417), the lake no longer exists, the Jyhún (or Oxus) having made a way for itself to the Caspian, into which it disembogues at a spot called Karlawn, as will be described hereafter in its proper place." Again, in describing the rivers of Asia, he said, "It is recorded in all the ancient books that from this point the River Jyhún (or Oxus) flows on and disembogues into the sea of Kharesm; but at the present day this sea no longer exists, the river having made for itself a new channel, which conducts its waters into the Caspian. The point of embouchure is named indifferently Karlawn and Akricheh. From Kharesm to the point where the river falls into the Caspian the greater part of the country is desert."

So much for the Oxus. With regard to the Jaxartes, this writer explained another point which was of some importance; for, although the Oxus might have been diverted into the Caspian, still, if the other river entered the Aral, it would still remain a sea. But it was stated as follows:—"The river of Khojend in the lower part of its course, passing into the desert of Kharesm, joins the Jyhún (or Oxus), and thus ultimately reaches the Caspian." From which passage he (the Chairman) understood that at that time, A. D. 1417, the Jaxartes below Otrar branched off from its present bed to the left hand along a line now marked by reeds and lagoons (see Meyendorf's map), and joined the Oxus between Kungrad and Khiva, the two rivers from that point flowing on to the Caspian in one and the same bed. This statement was of the more importance as it came from a writer thoroughly acquainted with the country. In addition to this, there was the testimony of the great Emperor Baber, who of course knew the geography of his own country, and who said that the Jaxartes in his time did not enter the Aral, but was lost in the desert. His (the Chairman's) belief was that it sometimes reached the Oxus, and was sometimes evaporated in the desert.

Such is the history of the Oxus and Jaxartes up to about the year 1500. From that time a second change began to take place. The rivers were then found to be going back into the Aral. It might not be generally known that Mr. Anthony Jenkinson, the agent of some English merchants,

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passed across Central Asia to Bokhara as early as 1550. He landed on the shore of the Caspian at Ming-kishlag, and came down the coast to a point where, as he heard, the Oxus had formerly disembogued into the sea; but he was told that the river had lately changed its course and gone back into the Sea of Aral. The ruler of the country, Abul-Ghazi Khan, who had left a most elaborate history of it, gave distinct details of this occurrence, and mentioned the very year in which the river began to return into the Aral. He related how the stream gradually dried up, and formed the sea as it at present exists. Evidence indeed could be given of the condition of the stream, almost year by year, from that time to the present; but it would be sufficient to state that every modern traveller who had passed through those regions had found the old bed of the River Oxus exactly where it was originally described. It was first brought to our notice by Mouravieff, a Russian agent, who passed from the Balkan bay to Khiva in 1819. Subsequently Arthur Conolly, who was afterwards murdered at Bokhara, attempted to cross from Astrachan to Khiva, and he also came upon the old bed; and lastly Mr. Vambéry, whom the Fellows might remember seeing at a meeting of the Society two years ago, in his famous journey across the Turkoman desert, traced the same broad river-bed, and found that it was perfectly well known as the ancient bed of the Oxus. Hence it seemed that there was sufficient evidence to show that in early times, say from the year 500 before the Christian era to the year 600 after the Christian era, both the rivers ran into the Caspian, the Aral being non-existent; that after that, up to the year 1300, they fell into the Aral; that for the next two hundred years—namely, from 1300 to 1500—they came back into the Caspian; and that then, at a fourth stage, they gradually flowed back into the Aral, and formed the sea as we now know it.

The changes thus noticed were very important in reference to what might be the future history of these rivers and these countries. It was quite certain that, as the Jaxartes was now in the possession of Russia, so the Oxus must also naturally and necessarily be, in the course of time. Now he would read what was stated by Russian writers as the probable result of that event. The Russians almost always called these rivers by the names of the Amu Daria and the Syr Daria, instead of the Oxus and the Jaxartes; but he would, in reading the extract, use the latter names as being better known:—

"The Oxus is, for many reasons, of great importance to Russia than even the Jaxartes. It disembogued at one period into the Caspian, and its bed to that sea still remains. Some are of opinion that the course of the river can be again directed to its ancient bed, while others consider it impossible to do so. It can, however, be positively asserted that the existing information on this point is very superficial and inaccurate, and the question will never be satisfactorily settled until a scientific expedition be sent by the Government to investigate it in all its bearings. The southeastern shores of the Sea of Aral are well adapted for uniting the Jaxartes with the Oxus, and encourage the hope that the united mass of water of two such great streams may force their way through the old bed to the Caspian. The importance of this connexion will readily be understood, when it is remembered that a water-route in continuation of the Volga will be thus created, which will extend for 3000 versts into the interior of Asia,

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and that the extreme points of this uninterrupted water-way will be St. Petersburg and the northern slopes of the Hindoo Koosh."

This was a result which he (the Chairman) considered highly probable, and he believed that many present at the meeting would live to see a direct water-communication from the Baltic to the vicinity of the Indian Caucasus, which was considered the natural geographical boundary of India. They must remember that already there was a direct water-communication from the Neva, by means of canals, to Lake Ladoga, and thence to the upper course of the Volga, and down that river to the Caspian. Then, crossing the Caspian, vessels could reach the mouth of the bed of the Oxus. He looked upon that prospect without any apprehension or dismay, regarding it as the natural extension of civilization, and believing that it would be for the general advantage of mankind.

3. *Professor Kekulé.*—It is with much satisfaction that we see it announced that Professor Aug. Kekulé of Ghent has been offered the directorship of the magnificent laboratory now nearly completed at Bonn. No chemist of his years has done as much, either theoretically or practically, for the establishment of the present views in organic chemistry. The law of saturation, which, as Wanklyn says, is to chemistry what the law of gravitation is to astronomy, we owe to Kekulé. It is therefore a most just recognition of his ability and service to tender to him the directorship of the Bonn laboratory.

3. *American Association for the Advancement of Science.*—The next session of the American Association will be held at Burlington, Vermont, and commence on the 21st of August next. Prof. J. S. Newberry is President for the year, and Dr. Wolcott Gibbs, Vice President.

OBITUARY.

Theophile Jules Pelouze, died on Friday last, the 31st of May, at his country house at Bellevue, close to Sévres. Born the 13th of February, 1807, at Valognes (Département de la Manche), he inherited his love for science and arts from his father, Edmond Pelouze, a man of great practical talents, formerly employed in the manufactory of Gobelins, and afterwards director of the gasworks of the Manby and Wilson Company at Paris. Pelouze the elder is known as the author of a great number of treatises on various branches of applied chemistry—on glass-making, on brick-making, on colors and varnish-making, on washing and bleaching for housewives, etc. His treatise on the last-named subjects was published under the name of his wife. His chief work, 'On the Manufacture of Gas,' was revised by his son, and came out in a second edition as late as 1859.

Young Pelouze entered life as a pharmaceutical chemist; but he was only twenty years old when Gay-Lussac made him his assistant, and published some of his researches conjointly with him. Three years later, in 1830, he became professor of chemistry at Lille. Here he examined the juice of beetroot, and, in conjunction with Kuhlmann, published a paper on its fermentation. From 1831 until 1847 he took the place of Gay-Lussac as Professor of Chemistry at the École Polytechnique, and at about the same time (1831) he was elected to supply the place of Thénard as professor at the Collége de France. Shortly after these elections Pelouze managed to go to Giessen, and to publish joint researches with Liebig on the ether contained in wine, to which they gave the name of œnanthic

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ether, but which was afterwards proved by Delffs to be identical with pelargonic ether. In 1833 Pelouze became Assayer, and in 1846 Controller (Vérificateur) of the Mint. He was elected a member of the Académie des Sciences in 1837. Of republican views, and much interested in politics, he became prominent through the revolution of 1848. The provisional government elected him to a place which until then belonged to the nobility or to the chief dignitaries of the state, that of President to the Board of the Mint (Président de la Commission des Monnaies). This position he held until his death. He became successively knight, officer, and commander of the Legion of Honor. His private laboratory for pupils in the Rue Dauphine closed when he opened a laboratory in the mint.

The number of papers published by Pelouze is very great. We can only mention here the most prominent of his researches. Among these none will be better remembered than the investigation recorded in his paper on the transformation of hydrocyanic acid into ammonia and formic acid. This paper was published in 1834, but the importance of his discovery became evident at a much later period, when hydrocyanic acid was first produced from carbon and nitrogen. Then it was that the transformation which Pelouze had effected by treating hydrocyanic with a strong solution of hydrochloric acid attained its remarkable position as the first instance of the synthesis of an organic body from its elements. At the time of the discovery its real importance could not be appreciated, but even then the relation of formic to hydrocyanic acid was of much interest. Next in importance to this memorable paper are several papers on the products of the dry distillation of lactic, malic, and tartaric acids. Pelouze discovered lactic anhydrid and lactid. Maleic and pyrotartaric as well as pyrogallic acid, if not actually discovered were, at least, chiefly studied by him. The salts of lactic acid were likewise examined by Pelouze, and described in several papers, one of which he published conjointly with Gay-Lussac.

A memoir on mustard oil was published by Dumas and Pelouze; another on asparamid (asparagine) and asparamic acid by Pelouze and Bourton, and a joint research on curarine was published by Pelouze and Claude Bernard. In mineral chemistry nitrosulphuric acid constitutes his chief discovery. In applied science numerous contributions, particularly on fulminates and the manufacture of percussion-caps, and above all on glass, were published by him at various intervals. Pelouze had an interest in large glass works at St. Gobin, and his last communication made to the Academy, some months ago, treated on the subject of this manufacture. A treatise on chemistry in five volumes by Pelouze and Fremy has seen three editions, the last of which was published in 1866. All these publications, if they do not place him among the very first French savants, will preserve his name permanently in the history of science. His great kindness of heart, and sincere and active interest for his pupils, will not easily be forgotten. There are and have been witnesses to these genial qualities in England. Professor Crace Calvert and the late Mr. Stoikowitch were assistants to Mr. Pelouze. During the last year important researches on aniline colors were carried on in his laboratory by MM. Girard, de Laire, and Chapoteaut.—*The Laboratory*, i, 182, June 8, 1867.

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EZEKIEL HAYES.—Mr. Ezekiel Hayes, whose name has appeared on the title page of this Journal as its printer, died suddenly on the 12th of May last. In all relations in life Mr. Hayes was a man of strict christian integrity; and throughout his connection with this Journal, he labored earnestly for the interests of both authors and publishers.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Lippincott's Vapor Index, or Psychrometric Calculator.*—The Vapor Index is a mechanical contrivance by JAS. S. LIPPINCOTT, Haddonfield, N. J., for finding, by inspection, the relative humidity of the air, from the readings of the wet and dry bulb thermometers.

In a circular card, near its margin, are twenty equidistant openings, through which may be seen on a larger card over which it turns a series of numbers (from 0 to 100), representing *wet-bulb* readings. Radially inward from these openings are corresponding ones, arranged spirally, and numbered from 0 to 25. These numbers are *differences* of wet-bulb and dry-bulb readings. The *relative humidity* is read off through the opening whose number is this difference in a given case, when the card is so turned that the wet-bulb reading is seen in the corresponding marginal opening.

The instrument is simple, and many may prefer it to a table of double entry, for obtaining the same results; although in our view such a table, printed on a smaller card than this, would be equally convenient, and more durable. But knowing of no such table on a card, we can recommend the "Vapor Index" as more easy of use than the large tables, such as Guyot's, and as sufficiently accurate for ordinary purposes. The wide distribution of the Vapor Index would tend to increase much the interest in making hygrometric observations.

Mr. Lippincott is deserving of much credit for his efforts to extend an interest in Hygrometry, both by this invention, and by an interesting paper in the Report of the Commissioner of Agriculture for 1865, in which he discusses the relations of atmospheric humidity to various important phenomena in Meteorology and Agriculture.

2. *General Problems of Shades and Shadows, formed both by parallel and radial rays, and shown both in common and in isometrical projection, together with the theory of Shading;* by S. EDWARD WARREN, C.E., Prof. Descript. Geom., etc., Rensselaer Polytech. Inst., Troy, N. Y., author of "Elementary Plane Problems;" "Drafting Instruments," etc.; "Elementary Projection Drawing;" "Elementary Linear Perspective;" and "Descriptive Geometry." 140 pp. 8vo, with 15 plates. New York, 1867. (John Wiley & Son).—In our last volume we briefly noticed Professor Warren's excellent "Plane Problems in Elementary Geometry," a work bearing on the science of drawing. In the work before us, the author treats with fulness and perspicuity, the subject of shades and shadows. The treatises of Prof. Warren are all well adapted for instruction in the the Engineering and other Scientific Schools of the land.

3. *The American Naturalist*, Nos. 3 and 4. Salem, Mass.—This new and valuable magazine fully sustains the character predicted for it, and realized in its first number. Its leading articles are of a popular character and such as to be read with interest, and understood by all classes, while its scientific miscellany, and correspondence, reports of the meet-

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ings of Scientific Societies, etc., make it indispensable to every naturalist. Its illustrations are of a character rarely equalled in similar works.

No. 3, contains, Some Errors Regarding the Habits of Our Birds, by T. M. Brewer, M.D.; the Food of the Sea Urchin, J. W. Dawson, LL.D.; the Royal Families of Plants, C. M. Tracy; the Moss Animals, or Fresh Water Polyzoa, A. Hyatt; the Tarantula Killers of Texas, G. Lincecum; the Birds of Spring, J. A. Allen; the American Silkworm, L. Trouvelot; the Land Snails of New England, E. S. Morse; Reviews, Natural History Miscellany, etc.

No. 4, contains, The Recent Bird Tracks of the Basin of Minas, C. F. Hartt; the Habits of the Gorilla, W. Winwood Reade; the Moss Animals or Fresh Water Polyzoa, concluded; the Land Snails of New England, continued; Parasitic Plants, G. D. Phippen; Oyster Culture, F. W. Fellowes; the Scorpion of Texas, G. Lincecum, M.D.; A note from the far North (Russian America), J. T. Rothcock; etc.

4. *Tables for Qualitative Chemical Analysis;* Professor Heinrich Will of Giessen, Germany. Seventh edition, translated by Charles F. Himes, Ph.D., Professor of Natural Science, Dickinson College, Carlisle, Pa. Philadelphia, Henry C. Baird, 1867.—Professor Will's analytical tables have, in the earlier editions, become familiar to American students through Faber's translation. They furnish, undoubtedly, the most compact classification of reactions yet published. Dr. Himes's translation being from the seventh German edition, is considerably improved. He proposes it as a suitable text book for laboratory instruction in those colleges who are assigning to Natural Science a more prominent place in their courses of study. The book is convenient in size (octavo), and is published in good style.

5. *The American Annual Cyclopedia and Register of Important Events of the year* 1866, embracing Political, Civil, Military and Social affairs, Public Documents, Biography, Statistics, Commerce, Finance, Literature, Science, Agriculture, and Mechanical Industry. Volume VI, 796 pp., large 8vo. New York, 1867. (D. Appleton & Co.)—Appleton's Annual Cyclopedia is a very important contribution toward the political, civil and geographical history of this and other countries, and also is full of valuable articles in the various other departments which it aims to have represented. The volume for 1866 has a portrait of the King of Prussia as its frontispiece, and beyond, others of Bismarck and Garibaldi.

6. *Eaton's Arithmetic and the Decimal System.*—Prof. H. A. Newton, who has been among the foremost in labors to secure the introduction of the decimal system into the United States, has prepared an admirable chapter on the subject, as an addition to a new edition of Eaton's Arithmetic. It occupies pages 337 to 348 of the arithmetic, and consists of tables, explanations, and examples, all of which are well adapted to introduce the subject to the student and make him practically familiar with it. In view of the recent act of Congress with regard to the decimal system, this department of arithmetic ought at once to make a part of all the text-books used in the schools of the country.

7. *Micro-chemistry of Poisons, including their physiological, pathological and legal relations:* adapted to the use of the medical jurist, physician, and general chemist; by Theo. G. Wormley, M.D., Professor of Chem-

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istry and Toxicology in Starling Medical College, and of Natural Sciences in Capital University, Columbus, O. xxxi, and 668 pp., 8vo, with 13 steel plates. New York, 1867. (Ballière Brothers).—Dr. Wormley has taken up the subject of poisons after a method wholly his own and has prepared a work of the highest merit, and practical utility. This volume treats first of the effects of poisons and the causes modifying them, the sources of evidence in cases of poisoning, and the methods of chemical analysis; and then proceeds to the special consideration of individual poisons, first the inorganic and then the organic. The new feature in his treatment of the subject consists in the use of the microscope for the study of the crystallizations resulting from the action of various reagents on the several poisons. The facts given are all from his own minutely careful experiments, and the results are exhibited with great perfection and delicacy on a series of plates from steel containing seventy-eight illustrations. The engravings are from the pencil and graver of Mrs. Wormley, and the artist, although but a novice in the latter art, has evinced that in such work she has no superior. We know not which to admire most, the masterly manner in which Dr. Wormley has treated his subject, the science of poisons, or the extreme beauty of the plates which supplement the text. The real practical value of the work the writer has already tested in connection with a case of poison by strychnine which he has now on hand. The Messrs. Ballière have issued the work in elegant style well comporting with its scientific merits. G. F. B.

8. *Chemistry of the Farm and the Sea, with other familiar Chemical Essays;* by Jas. R. Nichols, M.D. Boston, A. Williams & Co., 1867, 123 pp.—This volume includes nine chapters on the chemistry of the farm, the sea, a bowl of milk, the dwelling, a kernel of corn, obscure sources of disease, local decomposition in lead aqueduct pipes, bread-making, and the sun. It is an interesting book and will serve a useful purpose in popularizing science, though it is marred somewhat by inflation of style and errors of treatment.

9. *Annual Report of the Trustees of the Museum of Comparative Zoology, together with the report of the Director*, 1866.—This, the eighth annual report, shows continued activity in increasing the already vast collections of the museum. The Director's Report contains a general statement of the present condition of the museum, and a somewhat detailed account of his Brazilian Expedition and its important results.

10. *The Art of Perfumery and the Methods of obtaining the Odors of Plants*, with Instructions for the manufacture of perfumes for the handkerchief, scented powders, odorous vinegars, dentifrices, pomatums, cosmetics, perfumed soap, etc., to which is added an Appendix on preparing artificial fruit-essences, etc.; by G. W. Septimus Piesse, Analytical Chemist. 2nd American from the 3d London Ed. 402 pp., 12mo. Philadelphia, 1867. (Lindsay and Blakiston.)

11. *The Art of Manufacturing Soap and Candles*, including the most recent discoveries, embracing all kinds of ordinary hard, soft, and toilet soaps, especially those made by the cold process, the modes of detecting frauds, and the making of tallow and composite candles; by Adolph Ott, Ph.D., Practical and Analytical Chemist. 194 pp., 12mo, with woodcuts. Philadelphia, 1867. (Lindsay & Blakiston.)

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The two volumes whose title pages are here cited are popular and practical works on the subjects of which they treat. The first dips somewhat into the history and esthetics of the art, as well as its science.

12. *Notice of Volume IV of the Paleontology of New York;* by JAMES HALL. 24 pp., 18mo. Published March, 1867.—We have barely space to announce the appearance of this pamphlet, just now received. It contains a brief statement of some of the views and facts which are contained in the forthcoming *fourth* volume of the Paleontology of New York, with lists of the species described. The limits and characteristics of several genera of Brachiopoda are discussed, and some points are illustrated by figures.

13. *Ueber die Verschiedenheit in der Schädelbildung des Gorilla, Chimpansé, und Orang-Outang, vorzüglich nach Geschlecht und Alter, nebst einer Bemerkung über die Darwinsche Theorie;* von Dr. TH. L. BISCHOFF, Professor der Anatomie und Physiologie in München. Mit 22 lithographirten Tafeln. München.—This work will be valuable to those engaged in the study of the Quadrumana, and especially to those interested in the comparison of their anatomy with that of man. The plates are of folio size, and admirably executed.

The part of the work which possesses most general interest, is of course the appended note on the Darwinian Theory. Some of the points are as follows.—The assertion so confidently brought forward that the anthropoid apes are the direct ancestors of man, is entirely unsupported by evidence; moreover it is even contrary to the Darwinian theory rightly understood, for the extinction of the parent form is the direct consequence of the development of an improved form. The great problem of organic nature is twofold: 1. The origin of the simplest original forms; 2. The causes and the mode of their operation, by which more perfect forms were developed. A great defect of Darwin's theory is that he leaves the first question unanswered. Admitting that certain organisms must have been created, what right has he to say that other organisms may not have been created at intervals, even to the present time? Another defect of the Darwinian theory is, that no cause is assigned for the commencement of variation. To say that organisms have at once the power of transmitting peculiarities by inheritance, and of spontaneously originating variations, is a contradiction in terms. Darwin's treatment of the second half of the second question is more successful. Natural selection and the struggle for life must henceforth be fundamental principles in any theory of development. Since no general cause is assigned either for the origin of life or for the commencement of variation, all that can be considered as proved is that certain forms have been produced by variation from certain other forms. The facts warrant no general induction. We must be very cautious in accepting plausible theories without sufficient proof. The vagaries of the "naturphilosophie" furnish an instructive example. The psychical difference between man and brute is not merely quantitative, but qualitative. The distinctive peculiarity of man may be designated as *self-consciousness* (selbstbewusstsein), or the faculty of making one's self and one's mental condition a distinct subject of thought. On this faculty depend other important peculiarities of man, viz., the capability of indefinite progress, the idea of morality, the notion of a future state, and the power of language.

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14. *L'Unita delle Forze Fisiche Saggio di Filosofia Naturale.* Del P. Angelo Secchi, D.C.D.G. 511 pp., 8vo. Roma, 1864.—The principal object of this work, as stated by the author, is to present to Italian readers an adequate representation and exposition, in their own language, of the modern doctrine of the unity or convertibility of natural forces, and of the principle of conservation of energy. The style is professedly adapted to the comprehension of the majority of readers, especially for those not deeply versed in science. But though, for this reason, divested of the appearance of abstruseness, and free from difficult mathematical investigations, it is not, in the proper sense of the word, a *popular* treatise. Important modern discoveries and theories are very fully cited, and everywhere the work bears evidence of extended research, and a wide acquaintance with the literature of modern science. Though there is little that is absobutely new in it, the book is valuable and interesting, being as it is an able exposition of principles which may almost be called the corner-stone of modern physics. There is probably no book in which the subject is more fully and satisfactorily treated than in this. The author appears to us to do but scant justice to Mayer, to whom the whole subject is so deeply indebted; for he does not even mention him in the preface, where are cited the names of those who have contributed most to this branch of science, and he makes subsequently but slight reference to his discoveries. A. W. W.

15. *Carte Hydrologique du Département de la Seine*, publié d'apres les ordres de M. Hausmann, Préfet de la Seine, et executée sur la carte topographique de l'Ingénieur des Ponts et Chaussées, par M. Delesse, 1862, 4 sheets.—This admirable map represents, as its title indicates, all the natural and artificial water-courses of Paris and its vicinity. The basis of the map is the topographical survey by Letellier and Potiquet, officers of the department of des Ponts et Chaussées. Its scale is 1 : 25,000. The curves of equal elevation are given at intervals of four meters. The map is tinted according to the geological formations. On a map of this character all the drainage by rivers, rivulets, sewers, gutters, etc., is accurately given. The execution of the work is excellent, and its practical importance is very great.

16. *Memorie dell' Observatorio dell Collegio Romano;* Nuova Serie, vol. II, dall' anno 1860 al 1863, Pubblicate dal P. Angelo Secchi, della Compagnier di Gesu, Direttore, etc. Roma, 1863. 4° (16 numbers), pp. 128.—This volume contains the astronomical observations made at the Collegio Romano during the period indicated in the title. The principal subjects are the Comets II 1861 and III 1862, the solar eclipse of July 18th, 1860, and spectral analysis of the light from the heavenly bodies. With these is given also a memoir upon the connection between meteorological varieties and those of terrestrial magnetism.

Diagrams are given representing the appearance of the two comets, of the solar eclipse, of the planets Jupiter, Mars and Saturn, and of about twenty spectra of the planets and fixed stars.

The relations of the second of these comets to the August meteors makes the numerous representations of its telescopic appearance of special interest.

17. *Quelques vües generales sur les Variations Séculaires du Magnétisme terrestre*, 1er Fascicule, par V. Raulin. 8vo, pp. 92. Extrait des Actes de la Société Linnéenne de Bordeaux; t. xxvi, 1867.—The author

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gives a large number of observations showing the secular variations of the magnetic needle in all parts of the earth. He explains them by a hypothesis similar to that proposed in this Journal, xxxviii, 69, 1840, by the late Chancellor Lathrop. Mr. Raulin supposes that a body of greater density than the fluid portion of the earth, more or less irregular in form, and having the properties of a magnet, forms part of the earth's mass, but is not attached to the external crust. The line joining the poles of this magnetic mass is directed along the chord that joins the actual magnetic poles of the earth. This mass does not rotate exactly with the earth's crust, but falls behind it one revolution in about 600 years.

18. *Annales Météorologiques de l'Observatoire Royal de Bruxelles;* publiés, aux frais de l'état, par le directeur A. Quetelet, 4°, première Année, 1867, Nos. 1–5 (Jan.–May).—These annals give, in 8 quarto pages for each month, observations at Brussels of the barometer and thermometer for 15 stated hours each day, with maxima and minima, observations of August's psychrometer four times a day, of Osler's anemometer 12 times a day, of the direction of the wind, the state of the sky, and the declination of the needle four times a day, and of the electricity of the air, and the amount of rain daily.

19. *The Laboratory:* a weekly record of scientific research. London. (James Firth.)—We have now received the 13th issue of this active little journal and find that it increases in value with every number. Originated to provide a more efficient means of interchange in thought between men of science, especially chemists, it has brought to the task men of the first ability; and now we see it announced that Prof. Kekulé has consented to contribute regularly to its pages. We commend "The Laboratory" to the notice of men of science, confident that the papers published in each number are well worth the price of subscription.

20. *The Record of Zoological Literature for* 1865. Vol. II. 798 pp. 8vo. Edited by Dr. Albert C. L. G. Gunther. (London, John Van Voorst).—A book almost indispensable for every working Zoologist.

21. *Chambers's Encyclopedia.*—The American edition of this important Encyclopedia, issued by Lippincott & Co., Philadelphia, has reached Part 115, which nearly finishes the letter T.

Mining and Metallurgy of Gold and Silver; by J. Arthur Phillips, Mining Engineer, Graduate of the Imperial School of Mines of France, &c. 8vo. Preparing for publication. (E. & F. N. Spon, London; J. Wiley & Son, New York.)

Notes upon the Geology of some portions of Minnesota, from St. Paul to the western part of the State; by James Hall. 12 pp., 4to. From the Trans. Amer. Phil. Soc., vol. xiii, 1867.

On the Distribution of Temperature in the lower region of the Earth's atmosphere; by Henry Hennessy, F.R.S., Prof. Nat. Phil. in the Catholic Univ. of Ireland. 58 pp., 4to, with a folded plate. Dublin, 1867. From the Trans. Roy. Irish Acad., vol. xxiv.

Proceedings Acad. Nat. Sci. Philadelphia, No. 1, Jan., Feb., March, 1867.—p. 2, On a new genus of Homoptera; *H. Skinner.*—p. 11, On some points in the Mammalian skull; *H. Allen.*—p. 13, On Itacolumite; *C. M. Wetherill.*—p. 15, On colonies of plants observed near Philadelphia; *A. H. Smith.*—p. 24, The Cutting Ant of Texas; *G. Lincecum.*—p. 31, Notice of a fossil skull of a large Turtle from the Cretaceous of New Jersey, Euclastes platyops; *Cope.*

Proceedings Bost. Soc. Nat. Hist., Vol. XI.—p. 71, Analysis of Meteoric iron of Colorado; *C. T. Jackson.*—p. 75, Diatoms of a deposit near L. Winisquam, in Laconia, N. H.; *R. C. Greenleaf.*—Diatoms of the White Mts., the minuteness, etc.; *C. Stodder.*—Infusorial Earth from Peru; *C. Stodder.*—p. 79, Diatoms and other microscopic objects of the Gulf of Mexico; *R. C. Greenleaf.*

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THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XIV.—*On Mineralogical Nomenclature;* by JAMES D. DANA. No. I. *On System in Mineralogical Nomenclature.*

MINERALOGICAL nomenclature had already a commencement of system among the old Greeks and Romans; and this system was the same as that of the modern science. It consisted in adding to the word signifying a quality, constituent, use, or locality of the stone, the termination *ites* or *itis;* and although, through the many ways in which names were originated and the absence of any scientific purpose, those of other kinds are numerous, this was the common method of forming names for objects in inorganic nature.

The following are a few examples, from Pliny's Natural History.

1. *Names derived from physical characters.*

Hæmatites, from *αἷμα*, *blood*, in allusion to the color of the powder.
Steatites, from *στέαρ*, *fat*, in allusion to the greasy feel.
Pyrites, (including millstones, as well as our pyrites, etc.) from *πῦρ*, *fire*, because supposed to have a peculiar affinity for fire, as shown by the sparks given out when struck.
Rhoditis, from *ῥόδον*, *a rose*, in allusion to the color.
Chloritis, from *χλωρός*, *green*, in allusion to the color.
Ceramitis, from *κέραμος*, a tile, or earthenware, from the color.
Ceritis, from *κηρός*, *wax*.
Iritis, from rainbow-like reflections.
Phengites, from *φέγγος*, *brightness*, in allusion to the transparency.
Selenitis, from *σελήνη*, *the moon*, in allusion to its reflections.
Molochitis (our Malachite) in allusion to its green color, from the Greek for the Mallow.

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Porphyrites, from πορφύρα, *purple.*
Prasites—πρασίτης of Theophrastus, from the leek-green color.
Crateritis, from κρατερός, *strong*, in allusion to the hardness.
Anthracitis, for a stone resembling coal in being black and yielding a black color when rubbed on a whetstone; also for another kind which resembled a burning coal.
Ophites, for stones having streaks of green color, like serpents.

2. *Names having reference to the form of the stone.*

Ostracites, for fossil shells.
Ostritis, a fossil oyster shell, or related species.
Phenacites, for stones resembling a date.
Botryites, " " a bunch of grapes.
Phycites, " " a seaweed, from φυκος, *a seaweed.*
Scorpitis, " " a scorpion in color or shape.
Dendritis, " " a tree.

3. *Names derived from the uses of the mineral.*

Alabastritis, for the stone (mostly, if not wholly, stalagmite) from which the kind of vase called *alabastron* was made.
Chrysites, from χρυσός, *gold*, it being used in trials for gold.
Basanites, from βάσανος, *a touchstone.*

4. *Names having reference to the constitution of the stone.*

Chalcitis, from χαλκός, *copper* or *brass*, for a copper ore.
Sideritis, from σίδηρος, *iron.*
Chrysitis (from the Greek for *gold*), Argyritis (from the Greek for *silver*), and Molybditis (from the Greek for *lead*), were names of products obtained in the reduction of silver ores; the first is supposed to have been a yellow litharge.

5. *Names derived from the names of localities.*

Pharanites, from the name of a locality in Arabia.
Syrtites, from a locality on the shores of the Syrtes.
Choaspitis, from a locality on the river Choaspes.
Syenitis, from Syene, in Egypt—probably the red Syenite of Syene.
Memphites, from Memphis in Egypt—a kind of marble.

The termination *ites* or *itis* was thus distinctive of the names of minerals, stones, or fossils.* Moreover, the names were derived from qualities, forms, uses, and localities, or from the same characteristics that are now referred to in making the new names of the science. The only modern kind of name not in vogue in Pliny's time is that *after persons.*

Werner appears to have been the first to introduce this class of names into Mineralogy. The earliest example, if I mistake not, was that of naming what de Born had called *Green Mica* (Mica viridis) *Torberite*,

* This termination does not come from the Greek word λίθος, *stone*, for this word when in composition retains in Latin names (and also in the modern German) its original form, as in *Chrysolithus.*

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after its investigator, the chemist Torber Bergmann (more correctly written *Torbernite* by some mineralogists of last century, as Bergmann, wrote his name in Latin, the language of his scientific works, Torbernus Bergmann). The name encountered objections; and Werner, in view of Bergmann's announcement (after some incorrect trials) that the mineral was a *copper* ore, substituted in 1789 the name *Chalcolite*. He however, immediately afterward (early in 1790) showed that he saw nothing bad in the style of name by designating other new species *Prehnite* and *Witherite*, the former after Col. Prehn the discoverer, and the latter after Dr. Withering the discoverer and analyst of the species. The same year, Estner, a mineralogist of Vienna, issued a pamphlet against the Werner school, with the title "Freymüthige Gedanken über Herrn Inspector Werner's Verbesserungen in der Mineralogie," etc., (64 pp. 16mo, 1790), in which he makes light of Werner's labors in the science, and under the head of *Prehnite* ridiculed this method of creating a paternity, and providing the childless with children to hand down their names to posterity (p. 25). Such names were, however, too easily made, too pleasant, as a general thing, to give and receive, and withal too free from real objection, to be thus stopped off, and they have since become numerous, even Vienna contributing her full share toward their multiplication.

As a part of the history of mineralogical nomenclature, it may be here added that Werner, when it was proved that his *chalcolite* was an ore of uranium with but little copper, instead of a true ore of copper, dropped the name entirely, and called the mineral simply *Uranglimmer* (Uranium mica); and Karsten, in his reply to Abbé Estner (Berlin, 1793, 80 pp. 12mo), makes out of the necessary rejection of chalcolite an argument against chemical names, and in favor of names after persons, as the latter could never turn out erroneous in signification.

During the Middle ages many provincial names for stones and ores originated, or came into use, in the mining regions of Europe; and some of these have since had general acceptance, such as Quartz, Blende, Hornblende, Talc, Feldspar, Schorl, Mispickel, Copperas (from Kupferwasser of the Germans, like Couperose of the French*).

In the course of the last century, when the science of minerals was taking shape, and progress in chemistry was helping it forward, there was an effort, on one side, to introduce, under the influence of Linnæus, the double names of other branches of Natural History; and, on the other, under the influence of Cronstedt and Bergmann, names expressive of chemical composi-

* The German word Kupferwasser, literally signifying Copper-water, (the *Chalcanthum*, and *Atramentum sutorium* of Pliny,) included the different vitriols, whether in solution or crystallised, which are a common result of the alteration of copper and iron pyrites and blende. Both the copper and iron pyrites passed for copper ores among the older miners from the Greeks down, and they occur mixed together along with blende in most mining regions. The words *couperose* and *copperas* have been supposed to come from the Latin *cuprirosa*. But *cuprum* gave *cuivre* to the French, and it is hardly a possibility that the Latin *u* should in another case, or ever, have become changed to the French *ou* instead of the sharp *u*; while the German *u* would naturally take this form.

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tion as far as it was ascertained; and the two methods have had their advocates till late in the present century. But, at the same time, the necessity of single names was recognized by most of the early mineralogists; and in the spirit of the system which had made its appearance among the Greeks and Romans out of the genius of the Greek language, they almost uniformly adopted for the new names the termination *ite*.

Thus we have from Werner the names Torberite, Chalcolite, Graphite, Prehnite, Witherite, Boracite, Augite, Pistacite, Pinite, Aragonite, Apatite, Leucite, Cyanite (Kyanite); and from other sources in the same century, Zeolite, Actinolite, Tremolite, Coccolite, Arendalite, Baikalite, Melanite, Staurolite, Lepidolite, Cryolite, Chiastolite, Collyrite, Agalmatolite, Sommite, Moroxite, Pharmacolite, Strontianite, Delphinite, Titanite, Ceylanite, Gadolinite, Rubellite, Sahlite, Wernerite, Scapolite, Mellite, etc.

The termination *ine*, was also adopted for a few names, as Tourmaline, Olivine, Mascagnine, Serpentine; and *an* in Vesuvian; but the great bulk of the names were systematically terminated in *ite*.

With the opening of the present century (in 1801), Haüy came forward with his great work on Crystallography, and in it he brought out a variety of new names that defy all system, having nothing of the system of the earlier science, and no substitute of his own. Forgetting that the unity of law which he had found in nature should be a feature of scientific language, he gave names to minerals as a gardener might to his varieties of pinks and roses, introducing thus the terminations—

ane, in Cymophane;
ase, in Euclase, Idocrase, Anatase, Dioptase;
aste, in Pleonaste;
age, in Diallage;
ene, in Disthene, Sphene;
gene, in Amphigene;
ide, in Staurotide;
ime, in Analcime;
ole, in Amphibole;
ome, in Aplome, Harmotome;
ose, in Orthose;
ote, in Actinote, Epidote;
yre, in Dipyre;
ype, in Mesotype.

And the true mineralogical termination *ite* he admitted only in the few following: Axinite, Meionite, Pycnite, Stilbite, Grammatite.

Haüy had commanded so great and so general admiration by his brilliant discoveries in crystallography, and by the benefits which he had thus conferred on mineralogical science, that

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his names with their innovations were for the most part immediately accepted even beyond the limits of France, although a number of them were substitutes for those of other authors.* Some of Werner's names were among the rejected; and a break was thus occasioned between German and French mineralogy, which will not be wholly removed until the rule of priority, properly restricted, shall be allowed to have sway.

Beudant succeeded Haüy, and had the same want of system in his ideas of nomenclature. Finding occasion to name vari-

* The *substitutes* among the above names in the 1st edition of Haüy's Crystallography (1801) are the following;

Amphibole, for *Hornblende* of last century and earlier.

Orthose, for *Feldspar.*

Pyroxene, for *Augite* of Werner, and *Volcanite* of Delamétherie. [Delamétherie was a contemporary of Haüy at Paris, the author in 1792 of an edition of Mongez's *Manuel du Minéralogiste* (after Bergmann's Sciagraphia); in 1797, of an ambitious speculative work entitled *Théorie de la Terre*, the first two volumes of which consisted of a Treatise on Mineralogy; in 1811, 1813, of *Leçons de Minéralogie*, in 2 vols., and for a number of years principal editor of the *Journal de Physique.* He gave offense to Haüy by some of his early publications. Haüy's mineral Euclase is described in full by Delamétherie in the *Journal de Physique* for 1792 (some years in advance of Haüy's description of it,) without crediting the name or anything else to Haüy: but five years later, in his *Théorie de la Terre*, he inserts the species with full credit to Haüy.]

Cymophane, for *Chrysoberyl* of Werner.

Idocrase, for *Vesuvian* of Werner.

Pleonaste, for *Ceylanite* of Delamétherie.

Disthene, for *Kyanite* (Cyanite) of Werner.

Anatase, for *Octahedrite* of de Saussure, and *Oisanite* of Delamétherie.

Sphene, for *Titanite* of Klaproth.

Nepheline, for *Sommite* of Delamétherie.

Triphane, for *Spodumene* of d'Andrada.

Amphigen, for *Leucite* of Werner.

Actinote, for *Actinolite* of Kirwan, and *Zillerthite* of Delamétherie.

Epidote, for *Thallite* of Delamétherie, *Delphinite* of de Saussure, and *Arendalite* of Karsten.

Axinite, for *Yanolite* of Delamétherie.

Harmotome, for *Andreolite* of Delamétherie.

Grammatite, for *Tremolite* of Pini.

Staurotide, for *Staurolite* of Delamétherie, and *Grenatite* of de Saussure.

And, later, *Paranthine*, for *Scapolite* of d'Andrada, and *Rapidolite* of Abildgaard.

Part of the changes were made with good reason. But others were wholly unnecessary. Haüy was opposed to names from localities, and hence several of the displacements. He objected also to names based on variable characters, and characters not confined to the species. Moreover, as his pupil, Lucas, observes (in giving reasons for rejecting the name *Scapolite* and substituting *Paranthine*,) "le vice du mot *lite*, qui s'applique à toutes les pierres, ne pouvoient plus convenir à cette substance du moment où elle seroit reconnue pour une espèce." Haüy's own names are remarkable, in general, for their indefiniteness of signification, which makes them etymologically nearly as good for one mineral as another, and very bad for almost none; as for example, *Diallage*, which is from the Greek for *difference; Analcime*, from *weakness* in Greek; *Orthose*, from *straight* in Greek; *Epidote*, from *increase* in Greek; *Anatase*, from *erection* in Greek, interpreted by him as equivalent to *length; Idocrase*, from *I see mixture* in Greek, etc. His name *Pyroxene*, which he defines *hôte ou étranger dans le domaine du feu*, is an unfortunate exception, as often remarked, the mineral being the most common and universal constituent of igneous rocks. It was a bad substitute for *Volcanite* of Delamétherie, and looks as if Haüy's adoption of it might have been prompted by repugnance to Delamétherie.

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ous mineral species which till then had only chemical names, he adopted Haüy's method of miscellaneous terminations, but indulged in it with less taste and judgment, and with little knowledge of the rules of etymology. In his work we find the termination *ese*, in Apherese, Aphanese, Neoctese, Acerdese, Mimetese; *ise*, in Leberkise, Sperkise, Harkise, (only German words Gallicized,) Melaconise, Zinconise, Crocoise, Stibiconise, Uraconise; *ose*, in Argyrose, Argyrythrose, Psaturose, Aphthalose, Rhodalose, Siderose, Elasmose, Exanthalose, Cyanose, Melinose, Disomose; *ase*, in Neoptase, Discrase; *ime*, in Ypoleime; *ele*, in Exitele; while names ending in *ine* are greatly multiplied.

With a little better knowledge of classical rules he would not have retained the terminal *s* of the Greek in the derivative, and thus have made the intolerable names above which end in *ose* and *ese*, and in part in *ise* (as *Siderose* from σίδηρος, *Aphanese* from ἀφανής, *Melaconise* from μέλας, *black*, and κόνις, *powder*); and with more of the spirit of system, he would have rejected entirely the plan of miscellaneous terminations.

In Germany, the tendency has always been to uniformity through the adoption of the termination *ite*. Breithaupt has been somewhat lawless, giving the science his Plinian, Alumian, Sardinian, Asbolan, etc.; his Castor and Pollux (no doubt regarded as a good joke, though in our view a joke out of place); his Glaucodot, Homichlin, Orthoclase, Loxoclase, Xanthocon, etc.; still, far the larger part of his numerous names are rightly terminated.

In view of the above and other considerations, we arrive at the following conclusions:—

1. The only chance for uniformity in mineralogical nomenclature is in the general use of the termination *ite*.

2. This termination is the best that is available, because of (1) its original use and signification, (2) its early origin, (3) its almost universal adoption in the science.

3. If any other termination in addition is to be used, it should be so only *under system;* that is, it should be made characteristic of a particular natural group of species, and be invariably employed for the names in that group; and its use should not be a matter of choice or whim with describers of species.

As a matter of fact, *ine* has not been employed for any particular division of minerals, or with reference to any system, and it could not now be so restricted; and, this being the case, it should be put out of the science as far as possible. It belongs by adoption and long usage to chemistry, and should be left to that science.

4. In order that the acquired uniformity may be attained, changes should be made in existing names, when it can be done without great inconvenience.

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Names like *Quartz*, *Garnet*, *Gypsum*, *Realgar*, *Orpiment*, with the names of the metals and gems, which are part of general literature, must remain unaltered. *Mica* and *Feldspar*, equally old with Quartz, have become the names of *groups* of minerals, and are no longer applied to particular species.

Fluor was written *Fluorite* last century by Napione. *Blende*, although one of the number that might be allowed to stand among the exceptions, has already given place with some mineralogists to *Sphalerite*, a name proposed by Haidinger (because blende was applied also to other species) in 1845, and signifying *deception*, like Blende. Galena was written *Galenite* by von Kobell some years since. Orthoclase, Loxoclase, Oligoclase might be rightly lengthened to *Orthoclasite*, etc. But the termination *clase* (from the Greek for *fracture*) is peculiar to names of minerals, and the abbreviated form in use may be allowed to stand for species of the Feldspar group. It seems better that it be avoided elsewhere. These remarks on special cases might be further extended; but it is unnecessary as I shall soon present my views more fully in another place.

There are of course objections to all such change. But the number of names requiring it are comparatively few; and hardly any of them are over sixty years old—a short time compared with the future of the science. Mineralogy is yet in its formative period; it is far from being so stiffened with age as not to admit of progress in the direction contemplated.

It has become very desirable that the nomenclature of rocks should have some point of difference from that of minerals. Names, like Diorite, Dolerite, Eurite, Porphyrite, Andesite, Tonalite, Phonolite, Leptynite, Domite, Dunite, Amphibolite, Pyroxenite, Pegmatite, Hyperite, Itacolumite, Spilite, Ditroïte, Sanidinite, Phthanite, Nephelinite, Miascite, Itabirite, Aphanite, are fast multiplying, and have nothing in them to indicate whether they are to be looked for or not in a work on mineralogy. It is, therefore, here suggested, as an easy method of giving the names of rocks a distinctive feature, to substitute for *i* in the final *ite* the letter *y*. Thus Diorite, Eurite, Tonalite, etc. would become Dioryte, Euryte, Tonalyte, etc. The *y* is already in the name *Trachyte*. The change would not be necessary in the familiar names Granite and Syenite. In the German language the terminal syllable *lite*, when from the Greek λιθος, is written *lith*, as in *Phonolith*; but it would be no disadvantage to the language, or to its science, if the *h* should be left off here as elsewhere, and the *yte* (or *yt* in German) be accepted as simply a termination in obedience to system.

In another paper I propose to discuss the bearing and limitations of the law of priority in mineralogical nomenclature.

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ART. XV.—*Observations and Experiments on living Organisms in heated water;* by JEFFRIES WYMAN, M.D., Hersey Professor of Anatomy in Harvard College.

IN a former number of this Journal (vol. xxxiv, July, 1862), an account was given of some experiments on the formation of Infusoria in boiled solutions of organic matter, the result of which was, that such solutions, exposed only to air which had passed through iron tubes heated to a redness, became the seat of infusorial life. The same result followed when similar solutions were enclosed in hermetically sealed flasks, and subsequently exposed to the action of boiling water. In a few instances Infusoria appeared when the temperature was raised above 212° F. All living beings found under the above circumstances have been attributed either, 1st, to organisms or the germs of them, supposed to be contained in the fluid experimented with, or the air included in the flasks; or 2d, to the direct transformation of organic matter into new living beings, independently of any germs or living organisms whatever; or in other words to "spontaneous generation."

Abundant proof has been brought forward to show that the spores or germs of infusoria exist in the air in quantities amply sufficient to account for the presence of living organisms in solutions freely exposed.

There can therefore be no certainty of the existence of spontaneous generation in a given solution, until it can be shown, that this has been freed of all living organisms which it contained at the beginning of the experiment, and kept free of all such from without during the progress of it. On the other hand, this kind of generation becomes probable, whenever it is made certain that Infusoria do appear in solutions, in which the conditions just mentioned have been complied with.

We say probable, because their appearance under such circumstances would not amount to a proof. The absolute proof of spontaneous generation must come from the formation of living organisms out of *inorganic* matter. If infusoria are generated in solutions of organic matter, independently of spores or germs, the question may be fairly raised whether we do not begin the experiment with materials in which life already exists, even though this material is not in the form of distinct organisms.

The issue between the advocates and the opponents of this doctrine, clearly turns on the extent to which it can be proved that living beings resist the action of water at a high temperature, or on what Pouchet calls "vital resistance," for in nearly all the observations hitherto made, heated water has been the agent for the destruction of infusorial life preliminary to the beginning of an experiment.

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The observations and experiments contained in this communication, have not been brought together either for sustaining or refuting the doctrine just referred to, but partly with the view of testing the accuracy of the experiments formerly made, and chiefly for the purpose of determining how far the life of certain kinds of low organisims is either sustained or destroyed in water which has been raised to a high temperature, a result which must be reached before spontaneous generation can be either asserted or denied. The evidence which will be adduced is derived from the following sources:

1st, from the phenomena of hot springs;

2d, from the appearance or non-appearance of Infusoria in solutions boiled for different periods of time, and exposed only to pure air;

3d, from the observed action of heat on the living organisms which the solution experimented with, was known to contain.

SECTION I. *Thermal Springs.*—The study of organisms living in thermal waters is of great importance in connection with the investigation of the limit of vital resistance. Having become adapted, through a long series of years, to their surroundings, such organisms may be supposed to live under circumstances the most favorable possible, for sustaining life at a high temperature. It is a well known physiological fact that living beings may be slowly transferred to new and widely different conditions without injury; but if the same change is suddenly made they perish. In the experiments made in our laboratories, the change of conditions is relatively violent and therefore liable to destroy life by its suddeness, when otherwise it might possibly have been sustained. In the thermal waters therefore which give us a range of temperature as high as 212° F., we are more likely to find the highest degree of heat consistent with the maintenance of life than in our flasks. The following accounts from different observers have been selected as giving the highest temperature at which life has been noticed in hot springs. It must not be overlooked, however, that these have been thus far very imperfectly studied, especially with regard to the lowest organisms, and that we are by no means sure that the extreme limit of endurance in them has been ascertained.

Hot Springs of Luzon.—These springs were examined by Sonnerat* and his account of them is often quoted as evidence that they are inhabited by fishes and plants at a temperature of 187° F.† This assertion is not sustained by those who have visited them since Sonnerat. Dr. Abel who accompanied Lord Amherst in his mission to China examined them, and "saw no fish, but a

* Journal de Physique, Avril, 1774, t. iii, p. 256.

† Spallanzani Opuscoli, Milano, 1826, p. 69.

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small snake and a frog which were not only dead but boiled."* Marion de Procé, who has examined the same springs with care states that the waters where the fish were actually found did not exceed 36° C. (or 96·8° F.)* Prof. James D. Dana, one of the naturalists of the U. S. Exploring Expedition also visited them; he makes no mention of animal life, but gives the important observation "that the stones were covered with a white incrustation which appears to be silicoeus, and a species of feathery vegetation occurs also upon those bordering the streamlets where the temperature is 160° F., and presenting various shades of green and white.†"

Hot springs of the Ouachita.—These are situated in Hot-spring Co., Arkansas, and the four hottest are stated by Major Long to have the temperature of 132°, 140°, 148° and 150° F., respectively. He says "not only Confervæ and other vegetables grow in and about the hottest of them, but great numbers of little insects are constantly seen about the bottoms and sides." "A small bivalve testaceous animal adheres to the plants and lives in such a high temperature."‡

Hot springs of Sorujkund.—Dr. Joseph D. Hooker found in these springs *Confervæ* which Berkeley referred to the genus *Leptothrix* "growing on the margins of the tanks and in the hottest water; the brown is the best salamander, and forms a belt in deeper water than the green; both appear in luxuriant strata, wherever the temperature has cooled down to 168° F., and as low as 90°." §

The hot springs of Pugha, in Thibet reach the temperature of 174° F., and *Confervæ* and *Oscillatoriæ* were found growing in them by Capt. Strachey.‖

Hot springs of Mariara and La Trinchera.—Humboldt has given the result of his own carefully made observations on the thermal waters of South America, among the most remarkable of which are those of Mariara and La Trinchera, and of these the latter is the hottest. Of La Trinchera he says, "We were surprised at the luxuriant vegetation that surrounds the basin; *Mimosas* with slender pinnate leaves, *Clusias* and fig trees have pushed their roots into the bottom of a pool, the temperature of which was 85° C. (185° F.), and the branches of these trees extend over the surface of the water at two or three inches distant." "An *Arum* with a woody stem, and with large sagittate leaves, rose in the very middle of the pool, the temperature of which was 70° C. (158° F.) Plants of the same species vege-

* Edwards, Influence of Physical Agents on Life. Translated by Dr. Hodgkin and Dr. Fisher. London, 1832, p. 466.

† Geology of the U. S. Exploring Expedition, p. 543.

‡ Long's Expedition to the Rocky Mountains, vol. ii, p. 291. Philadelphia, 1822.

§ Himilaya Journals, vol. i, p. 27. London, 1854.

‖ Ibid, vol. ii, p. 379.

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tate in other parts of those mountains at the brink of torrents, the temperature of which is not 18° C. (64·4° F.)*

Hot springs of California.—I am indebted to Dr. William H. Brewer, Botanist to the Geological Survey of California, and to Mr. William T. Brigham of Boston for the information which follows, in relation to the thermal waters of this state which they have personally examined. Dr. Brewer's observations as will be seen by the following extract from his letter to me, show the existence of plants in water of a considerably higher temperature than even that of La Trinchera. He says, "the place where the greatest temperature was noticed, in which plants occur is the Geysers, in Lake (formerly Sonoma) county about seventy-five miles north of San Francisco. Vegetable forms flourished in these waters at various temperatures up to 93° C., (199·6° F.,) but were most abundant in waters of the temperatures of 52° to 55° C. (125°–131° F.)"

"At the higher temperature they were not abundant and existed as grains like Nostoc or Protococcus, intensely green and rather dark. They were observed in several cases where the water was above 90° C., but were more common in the streams, as the water cooled, and formed large slimy masses. Much of these were in long slender filaments like Confervæ."†

"The temperatures given here were carefully observed with a standard centigrade thermometer, with a naked elongated bulb."

Mr. Brigham visited the same springs and made a collection of some of the Confervoid plants growing in them. In regard to animal life he says, "although I looked with great care I could find no living animals in the water, but boiled insects were rather common. These were not fair cases, as the waters were so strongly impregnated with sulphur and acid that these alone might account for the absence of animal life. On the bank where the temperature ranged from 197° to 207° F., spiders were abundant and seemed to feel no inconvenience from the heat. I saw several feeding on the bodies of insects boiled by the water. The spiders were seen even standing on the water which was 176° F.; their bodies were not immersed and the hairs on the legs might, as is often the case, repel the water."

Hot springs of Iceland.—"Mr. Flourens exhibited to the Academy, Confervæ collected in Iceland by M. Descloizeaux who found them growing in the Gröf at a temperature of 98° C., or 208° F."‡

Many other accounts§ of living organisms in thermal waters

* Personal Narrative, Bohn's edition, London, 1852, vol. ii, p. 38.

† Since the above was written. Prof. Dana and Dr. Brewer have published in this Journal, 1866, vol. xli, p. 389, various observations and remarks in relation to life in hot springs and in high temperatures.

‡ Comptes Rendus de l'Academie des Sciences, xxiii, 1846, p. 934.

§ See Edwards, Influence of Physical Agents on Life, London, 1832, p. 407. Carpenter, Gen. and Comp. Physiology, Philadelphia, 1851, pp. 57 and 70.

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might be given, but they relate mostly to a temperature lower than that of those already mentioned. Our object has been to bring together only the hottest, and with regard to which the evidence is trustworthy.

The statements we have quoted give satisfactory proof that different kinds of plants may live in water of various temperatures, as high as 168° F., as observed by Dr. Hooker in Sorujkund, 174° as observed by Capt. Strachey in Thibet, 185° as observed by Humboldt in La Trinchera, 199° as observed by Dr. Brewer in California, and 208° as observed by Descloizeaux in Iceland. The lowest forms only are found in the hottest waters.

With regard to animals the testimony is much less complete. The highest temperature at which they have been found, in so far as we have seen any evidence was, as stated by Major Long, 150° F., in the hot springs of the Ouachita where he found "bivalve testaceous animals" and insects. In the instance mentioned by Mr. Brigham, although the spiders were in air the temperature of which was from 197° to 207° F., it is doubtful whether their bodies were as hot. They are air-breathing animals, but it is not unlikely that the heat of their bodies is kept down as in others whose breathing is aerial by the evaporation from their respiratory and other surfaces. Otherwise it does not appear how the albuminous matter in their fluids is kept from coagulation. When walking on the surface of the water it is most probable, as Mr. Brigham suggests, that their feet are not immersed, but that these, as in Hydrometro, repel the water; the insects therefore might be wholly surrounded by air, in which case the temperature would be lower than that of the water. If a thermometer be held a short distance, not exceeding a half-inch, from the surface of boiling water, the temperature indicated will be many degrees below the boiling point. A marked difference exists even when the bulb and water nearly touch.

To show the importance of great accuracy in determining the temperature at the precise spot where the organisms are found we will cite the following statement, where a very erroneous result would have been obtained if the temperature of the surface-water had been taken as representing that of the whole mass. Tripier in his account of the baths of Hamman-mes-Koutin, in Algeria, saw fishes in water the surface of which had a temperature of 56° C. (132° F.), but in the lower layers from which the fishes did not rise, the thermometer indicated only 40° C. (104° F.) It is to be feared that this possible difference of temperature has not always been kept in view, by those who have reported the existence of animals in water of a high degree of heat.

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Dr. Carpenter in his General and Comparative Physiology mentions several instances of animals living in a high temperature and also states, that "at the island of New Amsterdam there is a mud spring, which, though hotter than boiling water, gives birth to a species of Liverwort."* It is presumed that this is the island of the same name referred to by Humboldt, but he only states that the springs in question were much hotter than those of the Mariara, which last were from 132° to 135° F.† It has also been asserted that Humboldt saw living fishes thrown out from the crater of Chimborazo at 210° F., and that they have been discharged at a higher temperature from the Geysers of Iceland.‡ In the first instance it was at Cotopaxi and not Chimborazo, that Humboldt made his observations. A species called *preñadillas* by the natives (*Pimelodus cyclopum*) is expelled from time to time from the crater, or clefts in the sides of it, in immense numbers; but he expressly states that the water expelled at the same time is not hot but cold and that the fishes are not so disfigured as to indicate that they had been exposed to a high temperature.§ We have not been able to find authority for the statement with regard to the Geysers.

SECTION II. *Experiments with boiled solutions of organic matter in sealed flasks.*—These experiments, which are divided into two series, were made for the purpose of ascertaining to what extent certain kinds of organic solutions became the seat of infusorial life, notwithstanding a more or less prolonged exposure to boiling water, and the precautions taken to exclude the entrance of infusoria from without. They are in part repititions of some of those formerly described, the results of which they fully confirm. Great pains have been taken to ensure accuracy in conducting, as well as in observing and recording them.‖

* Gen. and Comp. Physiol., 3d edition, Philadelphia, 1851, pp. 57 and 70.

† Humboldt's Personal Narrative, London, 1852, vol. ii, p. 24.

‡ Bibliothèque Universelle de Geneve, tome xx, p. 204, 1839.

§ Humboldt, Recueil d'Observations de Zoologie et d'Anatomie Comparée, 4to. Paris, 1811, p. 21.

‖ M. Milne Edwards in referring to the former series of experiments reported by the writer of this article and to others similar to them, questions their accuracy, since they do not agree with those of M. Pasteur, and thinks the difference in the results depended upon a defective mode of conducting the experiments. The process employed in some of them was identical with that employed by M. Pasteur himself, and in others, with that made use of by M. Milne Edwards in his one experiment (see his *Leçons sur la Physiologie et l'Anatomie Comparèe*, t. viii, pp. 260, 269.) When flasks, holding organic fluids and air, are hermetically sealed and boiled for from fifteen minutes to three or four hours, and infusoria make their appearance nevertheless, the experiment cannot be called a faulty one, so long as only these results are claimed. The recent experiments of Dr. G. W. Child of Oxford, England, and those reported in this communication are a sufficient answer to the criticisms of M. Edwards. The experiment of Pouchet recorded in his *Nouvelles Experiences*, Paris, 1864, p. 224, is conclusive as to possibility of Infusoria appearing in boiled solutions exposed to pure air.

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SERIES A. The flasks used in this series had a capacity of about 800 c. c. and had a long and slender neck; this was drawn out, about an inch from the end to a size which could easily be melted in a flame and in some instances the stem of a clay pipe, with a calibre of 0·08 inch, and in others, a copper tube 0·18 inch in diameter and filled with fine wires, was cemented into the mouth. The fluid in the flasks was boiled and thus the contained air expelled and replaced by steam. After the boiling had been continued sufficiently long, the whole was then allowed to cool slowly, the air to reënter through the tube, which last was kept meanwhile at a red heat. After the flask was cold it was hermetically sealed, the heat of the tube being carefully kept up until this was accomplished. Thus a boiled organic solution was obtained, in contact only with air which had been purified by heat.

Exp. I.—The contents of the flask were a few grains of meat and sugar, and 20 c. c. of water boiled 25 minutes. An infusorial film was formed on the 5th day; the flask was opened on the 31st. Vibrios were found in large numbers.

Exp. II.—50 c. c. of beef-juice and water were boiled twenty minutes. On the 4th day a thick infusorial film was formed over the whole surface of the fluid; the flask was opened on the 6th day and found to contain Vibrios and Bacteriums.

Exp. III.—The flask contained a small piece of beef weighing about three grammes, and 50 c. c. of water, which were boiled 30 minutes. An infusorial film was formed on the 3d day, which sank to the bottom and was afterwards replaced by another.

The flask was opened on the 27th day; the contents had a nauseous odor but were not putrid. The muscular fasciculi had fallen to pieces and the fluid had become slimy and viscid. Immense numbers of Monads filled the solution. Some feathery crystals were noticed, but the most striking circumstance in this as well as in some other instances in which muscle was used, was the fatty degeneration of the fibres which had taken place subsequently to the boiling. The fibres were found in many stages of change, some of them having their contents finely granular, striæ still seen, while others were filled with oil-globules, and had no traces of striæ left. One specimen was examined by Dr. Calvin Ellis who was unable to recognize any difference between the appearances which it presented and those of ordinary fatty degeneration of the muscles.

Exp. IV.—The flask contained very thin wheat paste mixed with saliva and water; the boiling was continued 25 minutes. No film was noticed until the 30th day, the flask was opened on the 68th day, and the fluid found filled with Monads.

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Exp. V.—A few grains each of meat and sugar in 20 c. c. of water were boiled 25 minutes. An infusorial film appeared on the 4th day. The flask was opened on the 50th day by Prof. Henry James Clarke by whom the accompanying figures were carefully drawn from nature.

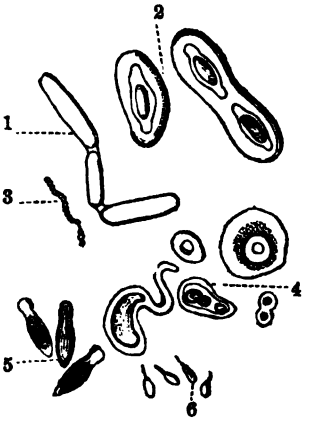

Fig. 1. *Vibrio baccillus*, enlarged two thousand diameters; these are very numerous and move quickly; the joints appear to be united by a gelatinous substance which is quite transparent and move on each other by a series of flexions and extensions; the number of segments is variable.

Fig. 2. *Bacterium;* enlarged four thousand diameters. Prof. Clarke has given especial attention to these bodies, and has shown that they are somewhat more complex than generally supposed. They consist of a dark colored oval nucleus, around which is a transparent space, and around this a gelatinous envelope of extreme delicacy. They are sometimes seen single but generally double; more than two are rarely united together.

Fig. 3. A linear series of globules enlarged five hundred diameters; these have the power of locomotion.

Fig. 4. Excessively faint and colorless bodies of great delicacy, and changing their form under the slightest pressure. They closely resemble the substance described by Virchow as *myeline* which not only forms the medullary sheath of the nerves, but is also found abundantly elsewhere. He says "there scarcely exists a tissue rich in cells in which this substance does not exist in large quantities."*

Fig. 5. This figure, also drawn by Prof. Clarke, represents an organism commonly seen in nearly all of the experiments. It is enlarged thirty-five hundred diameters.

Fig. 6, represents the form of the bodies we have called Monads, and each has a ciliated appendage and is locomotive.

Series B.—The flasks in which the experiments described below were made, all had the same capacity, viz. about 70 c. c., and the quantity of solution used in each was from 5 to 8 c. c. After the fluid to be experimented with had been introduced they were sealed at the temperature of the room, placed in a covered vessel containing water, and the whole heated to 212° F., and boiled for various periods.

This method corresponds substantially with that of the Need-

* Cellular Pathology, translated by Dr. Chance, p. 234. London, 1860.

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ham and Spallanzanni. It is in all respects more simple and easier than that in which the apparatus is complicated with a heated tube. This last beyond a question destroys all organisms contained in the air which enter the flask through it, but is without effect on such as may be contained in the solution, or adhere to the inner surface of the glass. These come in contact only with boiling water or steam, and unless destroyed by one or the other of these, would be sufficient to vitiate any experiment, however careful the adjustment and heating of the tube may have been. We therefore believe that the tube is an unnecessary and useless complication of the apparatus.

Exp. VI.—Six flasks prepared as above, and containing from 5 to 8 c. c. of beef juice and water were boiled 30 minutes. The albuminous matter was coagulated, but the fluid portion became perfectly transparent. The contents became turbid and an infusorial film was formed in four of the flasks on the 7th day, and a few days afterwards in the others.

Exp. VII.—Six flasks, each containing about 1 gram of beef and 5 c. c. of water were boiled 30 minutes. An infusorial film was formed on the surface of all of them on or before the 7th day.

Exp. VIII.—A single flask containing a few grains of finely ground bean flour and 5 c. c. of water was boiled 48 minutes. The mixture became filled with Vibrios on the 4th day.

Exp. IX.—Six flasks containing beef juice and water were boiled 30 minutes. A thick infusorial film was formed in all of them on or before the 7th day.

Exp. X.—Six flasks containing each a few milligrams of beef and 5 c. c. of water were boiled 30 minutes. An infusorial film was formed on all on or before the 17th day.

In the preceding experiments of this series, the boiling was continued thirty minutes in four, and forty-eight in the fifth. The following experiments were made for the purpose of ascertaining whether prolonged boiling would be attended with a different result.

Exp. XI.—Five flasks, each containing a few grains of beef, and about 5 c. c. of water were prepared as in the preceding experiments; one was boiled 32 minutes, one 50 minutes, and the other three 1 hour and 20 minutes each.

An infusorial film formed in the first on the 2d day, in the second on the 6th day, in one of those boiled 1 hour and 20 minutes on the 8th, and in the others on the 10th. All were examined and found to contain *Vibrios* and *Bacteriums;* and in addition the first and second contained the "myeloid substance" already described, fig 4. Those which were boiled longest were the latest in developing infusoria; but of those boiled 1 hour and 20 minutes, they appeared two days later than in the other.

Exp. XII.—Twenty-four flasks each containing about 5 c. c.

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of beef juice were divided into six series of four each, and boiled for different periods as indicated in the following table; this table also gives the day of the appearance of the infusoria in each of the flasks belonging to a given series.

Series.	Time boiled.	Day of appearance of Infusoria.			
I.	0^h 30^m	3	4	6	0
II.	0^h 45^m	4	4	4	4
III.	1^h 00	4	4	4	0
IV.	1^h 15^m	4	4	0	0
V.	1^h 30^m	4	0	0	0
VI.	2^h 00	0	0	0	0

Seven of the flasks produced no infusoria, and the number in which they did appear becomes less the longer the boiling was continued.

Exp. XIII.—Of seventeen flasks containing beef-juice eleven were boiled 45 minutes, and 6 were boiled 2 hours. Infusoria appeared in all of the first series except one, at the end of the second day, and in the remaining one of this series and in all of the second on the 3d day.

It will be seen at a glance that Expts. XII and XIII differ in their results, and that of four flasks in Ex. XII boiled 1 h. and 30 m., three produced no infusoria, while in Ex. XIII the infusoria appeared in all, six of which were boiled two hours. We have several times met with similar differences in successive experiments. Sometimes flasks boiled for a single hour became wholly inert, even when the number of them was quite large. We can only insist that in the above experiments the flasks were properly sealed, and that there was no error as to the time for which the boiling was kept up.

Exp. XIV.—Twenty flasks containing extract of beef were treated as follows:

	No. of flasks in each series.	Time boiled.	Day on which infusoria appeared.				
Series I.	5 flasks.	1^h	6	6	6	6	6
" II.	5 "	2^h	6	6	6	6	7
" III.	5 "	3^h	6	0	0	0	0
" IV.	5 "	4^h	0	0	0	0	0

No flask was opened until the sixth day, though there were slight indications of infusoria three days previously; actively moving Vibrios were found in large numbers. The experiment was discontinued on the 10th day, as there was no indication of further change.

Exp. XV.—Thirty-two flasks containing a boiled solution of "extract of beef"* were arranged in six series, and boiled for different times as seen in the following table:

* This is Borden's concentrated juice of beef, evaporated to a nearly solid substance, is free from tissues, and is entirely soluble.

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	No. of flasks in each series.	Time boiled.	Day on which infusoria appeared.				
Series I.	5	$0^h\ 30^m$	1	1	2	2	2
" II.	5	1 00	2	2	2	2	2
" III.	5	1 30	2	2	2	2	2
" IV.	5	2 20	1	2	2	2	2
" V.	5	3 30	2	2	3	3	?
" VI.	7	4 00	2 4	2 4	2	4	4

An infusorial film formed in all the flasks on the days indicated, except in the one marked doubtful in series V, and those of series VI, in which infusoria appeared on the 4th day. None of these last had a film, but, as in the one marked doubtful in series V, had an immense number of minute bodies, which formed a cloud when the flask was shaken, and were not there when the experiment was begun. These bodies were spherical, had an outer wall, and a nucleus which was also a hollow body. They were of different sizes, and seemed to be undergoing multiplication by division. Their real nature must be considered doubtful. The films in the other flasks consisted chiefly of Bacteriums.

The preceding experiments show that if the boiling of the flasks be continued for four hours, as in Exp. XV, the infusoria may appear nevertheless—though in other cases it has happened, as in Exp. XII, that life ceased to be manifested if it was continued only for two hours.

In pushing the experiments still further, we have not found that infusoria appeared in any instance if the boiling was prolonged to five or six hours. Several experiments, in which many flasks were used, were tried, but the result was uniformly the same. Thus a limit to the development of infusoria in boiling water was reached.

SECTION III. *Experiments to show the effect of boiling water on living infusoria.*—In view of the results given above, viz., the development of infusoria in sealed flasks, notwithstanding the precautions taken, the question naturally arises whether the infusoria which appeared were already in the flask and resisted the action of the water at 212° F. If not, then the invasion of the contents of the flasks by them is easily accounted for, since experiment shows that even a very few individuals if present may multiply so rapidly as to fill and make turbid a given solution in a very short time. But on the other hand, if the infusoria perish during the boiling, then any subsequent appearance of them under the circumstances, must be explained in some other way than by the common process of reproduction.

Since large numbers of infusoria can be proved at all times to be floating in the air, we must assume that some are included in every flask, and since certain organisms live in thermal

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waters at a very high temperature, within a few degrees even of boiling water, the experimenter is called upon to show whether water at the boiling point is or is not destructive of life, before he can venture to offer a theory of the origin of the infusoria in the flasks. It should not be overlooked that a marked difference exists between the conditions of life in the flasks and the thermal springs; in the former, the temperature is suddenly raised from that of the air to the boiling point, while in the latter, the organisms inhabiting them have become adapted to their surroundings through long periods of time. Furthermore it must be remembered that in the two cases, we have to deal with widely different species. It therefore becomes necessary to determine by direct experiment on the species of infusoria found in the flasks what *their* powers of resistance are.

Before proceeding to give the result of the experiments we have made, bearing upon this question, we will notice some of the statements which are constantly urged in support of the opinion that infusoria are capable of resisting water of a very high temperature. Among these are the ones relating to the well known experiments of Doyére and others, in which Tardigrades and Rotifers are asserted to have resisted a heat of 248° F. In these cases the important condition that the organism was in a *dry* and not in a moist state is often overlooked. In truth Doyére himself expressly mentions that in a *moist* condition they perished at 122° F.*

In the alleged instances of seeds resisting the action of boiling water, it may be reasonably doubted whether in these the results have not been misunderstood. Spallanzanni clearly proved that if the seeds experimented upon by him were soaked previously to the boiling, they did not germinate.† So long as the water does not penetrate to the germ, this is no more influenced by it than if the germ were exposed to dry air heated to the same degree, and this it easily resists. Water penetrates the seeds of many plants and especially of some of the *Leguminosæ* very slowly; in the case of those of *Gleiditchia* and *Laburnum*, we have found several days and even weeks necessary for the complete penetration of cold water, though when the water is hot it penetrates much more readily. If therefore the seeds are dry when immersed, and are boiled for a few minutes only, they may still germinate. If they are moistened beforehand, the action of boiling water has been found uniformly fatal. In one of our experiments twenty-eight seeds of *Gleiditchia* were soaked

* Annales des Sciences Naturelles, t. xviii, 1842, p. 29. The whole subject as regards the resistance of *dried* Rotifers to heat, was investigated in an exhaustive manner by a commission consisting of Balbiani, Berthelot, Brown Sequard, Dareste, Guillermen and Robin. See Comptes Rendus et Memoires de la Societé de Biologie, 1860.

† Oposcoli, Milano, 1826, p. 63.

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until their coverings became soft and swollen; one half were planted at once, and the others after having been boiled five minutes. None of the boiled ones germinated while all the others did. Similar experiments with beans and with several other kinds of seeds ended in a similar manner.

Pasteur has given the result of his own observations on the effects of high temperature on the spores of some of the different kinds of Cryptogams, and states that they resist when dry 248° to 257° F., but perish at 266°.* He gives no experiments in which the spores were exposed to heated water, or to steam. He excuses himself, however, on the ground of being unable to devise a sufficiently rigorous method of experimentation.† We believe the alleged difficulty can be met, and shall endeavor to show by a series of comparative experiments that definite results may be obtained. From the manner in which Pasteur states his own results, he gives the impression that in view of the fact that the spores resist when *dry* a temperature of 257° F., it is reasonable to suppose that they will resist 212° when *moist*. He does not assert this, but leaves his reader to infer it. We have tried many experiments upon different kinds of moulds and yeast plants and have found, as nearly all observers have, that they perish at 212° F. Every one is familiar with the process of "scalding" in domestic economy, which destroys the kinds of cryptogams ordinarily concerned in fermentation, and on the efficacy of which the preservation of canned meats and other articles depends. As regards moulds the following experiment is decisive. Take any number of cups of paste and sow them all freely with spores; put one half in a covered vessel containing a small quantity of water; boil this for a few minutes, thus exposing the paste and spores to steam, and then set all the cups in similar conditions for light and heat; none of the spores in the series which has been steamed will germinate, while all others will.

Payen is quoted by many writers as asserting that the spores of *Oidium aurantiacum* germinated after having been exposed to 248° F. Pasteur himself expresses the belief that in this case the temperature has been erroneously determined.‡ Payen's own statements are somewhat conflicting. In the one most commonly quoted he says that spores heated in ordinary dough to 120° C. (248° F.), may still germinate, but are so altered at 140° C. (284° F.) that they do not germinate.§ In another and later statement he presents the matter quite differently. "The spores of *Oidium*," he says, "preserve their vegetative faculty in the soft part of the bread, (*la mie du pain*) the tem-

* Ann. des Sc. Nat., t. xvi, 1861, p. 81. † Ibid., p. 85.
‡ Ann. des Sc. Nat., t. xvi, 1861, p. 81.
§ Ann. de Chim. et de Phys., 3me serie, t. xxiv, 1848, p. 254.

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perature of which does not exceed 100° C. during the baking;* while in the crust, the temperature which exceeds 200° C. (392° F.) destroyed the vitality of the *Oidium*."† There are here two conditions of the bread recognized; the moist interior which destroys the spores at 212° F., and the dry exterior which does so at 392° F. Mention has also been made of the germination of seeds taken from the raspberry jam, as proof that these had resisted the action of boiling water. But in none of these cases have we seen any evidence adduced to show that they had really been boiled. We have not been able to find a single instance in which seeds or spores or infusoria, excepting only Vibrios, Bacteriums and Monads, thoroughly moistened before the experiment, have resisted the prolonged action of boiling water.‡

The organisms which we have most commonly met with in our experiments in flasks, in fact almost the only ones, when the boiling was prolonged, are *Vibrios*, *Bacteriums* and *Monads*. The first and second are without doubt plants allied to the *Algæ;* the nature of *Monads* is more obscure. They are all among the lowest of living organisms. Leaving out of consideration ciliated infusoria which perish more easily, our inquiry now is, *at what temperature, or after how long an exposure to the action of boiling water are the Vibrios, Bacteriums and Monads killed, and by what signs can we know that they are dead?*—This question is a difficult one to answer.

The usual signs of life manifested by the infusoria found in the flasks are the following: 1st, locomotion in nearly all of the species; 2d, growth and reproduction; 3d, their reaction on the surrounding fluid, producing fermentation or putrefaction. The second and third are so intimately associated that the presence of one is almost a certain indication of the other. If a clear organic solution ferments, or becomes turbid, it may be safely inferred that living infusoria are present; nevertheless the correctness of this inference must be tested with the microscope. The absence of either of the above signs *alone* cannot be considered as a proof of death, and under certain circumstances all *signs* of life may cease, but the infursoria may still be alive. If for example, they are developed in a sealed flask, as soon as the organic matter convertible into infusoria is exhausted their activity ceases, and they remain dormant for months; we have kept them in this way for a year; but if fresh material is supplied to them, they at once resume their activity. Inactivity *in the presence* of organic material suitable for nourishment, and of

* The baking in this case was for the purpose of destroying the spores in loaves in store, and not for those going into the oven for the first time.

† Precis de Chim. Indust. Paris, 1859, t. ii, p. 150.

‡ The assertion of M. Coste, that encysted infusoria resist the action of boiling water, has been shown to be incorrect by the conclusive experiments of M. Victor Munier.

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air at the ordinary temperature, added to the absence of the other signs of life, must be considered as the best indication of death.

1. *Arrest of motion.*—The temperature at which motion ceases was determined as follows: a wide-mouthed bottle containing infusoria was set in a water-bath, and a thermometer suspended with its bulb in the infusorial fluid. The whole was gradually heated, and drops of the fluid were examined from time to time with the microscope, until the motions of the infusoria ceased. The following table gives the result of the examination of fluids taken from several different sources. The movements of the Vibrios lasted longer than those of all other kinds, and the temperature given below is that at which the motions of these were arrested. The motion of all the ciliated infusoria stopped at less than 130° F.

Motion ceased	Experiments I.	II.	III	IV.	V.	Average.
	°	°	°	°	°	°
In infusoria from a macerating tub at	57·5	57·0	56·0	57·0	56·0	56·7 C. = 134·06 F.
In infusoria from another tub at	55·0	57·0	58·0	57·0	58·0	56·4 C. = 133·00 F
In infusoria from beef juice at	55·0	54·0	55·0	54·0		54·5 C. = 130·00 F.
In infusoria from a source not stated at	57·0	55·0	56·0			56·0 C. = 132·90 F.

2. *Arrest of growth and reproduction.*—In the following experiments as a matter of convenience the temperature was always carried to the boiling point, though it by no means follows that this was in all cases necessary. The object was to determine by comparative experiments, whether the growth and reproduction of the infusoria and their reaction upon a given solution is arrested or modified by their having been exposed to boiling water. The solution used in nearly all was beef juice,* obtained by grinding up flesh with water, which was poured off, boiled and filtered; it thus became limpid and well adapted to show the slightest change in transparency which attends the development of infusoria. Equal quantities of the solution were poured into a given number of bottles, and these were divided into three series. Those of the *first* were set aside as criteria; to each of those of the *second* was added a drop of water containing active infusoria; to each of those the *third* was added a drop of the same fluid as in the second series, but after it had been boiled. All were placed together, having a similar exposure to light and heat. By a comparison of the results of the second and third series it will be seen whether the boiling has perceptibly affected the growth and reproduction of the infusoria; by a comparison of the results in either the second or third series with those of the first, the difference will be shown between the effect of adding boiled or unboiled infusoria on the

* In some of the later experiments, instead of beef juice prepared as above, a solution of Borden's "extract of beef" was used.

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one hand, and the simple exposure of the solution to the air without the addition of either, on the other. When an open bottle was used it was in most cases covered with a paper cap to exclude in a measure the dust from the air; this exclusion was of course incomplete, but as all the flasks were equally exposed and large numbers were used, any disturbance would be the same for all, and might therefore be left out of the account. As will be seen further on we have not depended solely on this form of the experiment.

Exp. XVI.—Eighteen bottles of the capacity of 25 c. c. and an inch in diameter throughout and containing equal quantities of boiled and filtered beef juice were divided into three series of six each. All of series I were set aside as criteria; to all of series II were added from a bottle five drops of water containing large numbers of living Vibrios taken from a fluid in which flesh was macerating; to all of series III were added five drops of the same infusorial fluid after it had been boiled five minutes.

On the 2d day all of series II, to which the unboiled infusoria had been added, were turbid from the rapid multiplication of the animalcules, and an infusorial film was formed on the surface of the fluid. All of series I and III were unchanged.

On the 3d day all of I and III had begun to be turbid, and on the 4th were equally so with II.

Exp. XVII.—Thirty-three bottles prepared and arranged as in the preceding experiment were divided into three series of eleven each.

On the 2d day all of series II were turbid and had an infusorial film. The others were unchanged.

On the 3d day eight of series I and seven of series III had become turbid and the rest became so on or before the 6th day.

From the above experiments it is obvious that the boiling of infusoria has a marked effect, since the solutions, to which boiled infusoria were added, did not become invaded by animalcules sooner than those to which none had been added, while those to which unboiled infusoria were added, were in all cases invaded at least one day and in some, two or three days earlier.

In each of the preceding experiments the bottles were all more or less exposed to the air, for the paper covering was only a partial protection. The following modification of them was tried, for the purpose of ascertaining if there would be any difference in the time in which infusoria would appear in portions of the same solution enclosed in two series of flasks, to one of which infusoria had been added, and all of both series sealed at the temperature of the room, and afterwards boiled for the same time. By performing the experiment in this way the influence of dust from the air was eliminated, excepting in so far as it was present in the flasks at the time they were sealed. This

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would be the same in both series, as it was in the preceding experiments, the only difference being that the quantity would be less, and there would be none which had not been boiled.

Exp. XVIII.—Nineteen flasks of about 75 c. c. capacity, each containing about 15 c. c. of boiled and filtered beef juice were divided into two series, one of nine and the other of ten flasks. All of series I were sealed at the temperature of the room, without any addition to their contents. After a drop of water containing active infusoria had been added to each of series II, these were also sealed at the temperature of the room, and then all of both series boiled 15 minutes.

They were allowed to stand twelve days in a cold room in the winter, when no change having taken place they were removed to a room in which the temperature ranged from 50° to 70° F., day and night. Six days later, on the 18th from the beginning of the experiment, five flasks of each series had become turbid, and on the 20th all had become so. There was no obvious difference between the two series in the time required for the development of the infusoria. A longer time passed before the infusoria appeared than in the experiments with the open bottles, but this is to be attributed in part to the coldness of the room in which they were at first placed. But even in the warm room it was six days before they became turbid.

Exp. XIX.—Seven flasks containing boiled and filtered beef juice were divided into two series—I, consisting of three flasks, had added to the above fluid in each one drop of infusorial fluid, and were sealed and allowed to remain at the temperature of the room. Series II consisted of four flasks prepared as in series I, but after being sealed were boiled 30 minutes.

At the end of 18 hours two of series I had become turbid but none of II. At the 25th hour all of I were turbid and two of II. On the 3d day three of II were turbid and on the 4th all were.

Exp. XX.—A fluid was prepared containing half a gram of extract of beef to 100 c. c. of water. Twenty-one flasks containing this fluid were divided into four series.

Series I, consisting of three flasks which were sealed at the temperature of the room.

Series II, consisting of six flasks, had added to each one drop of dust fluid; this last was made by adding three or four grams of dust from the tops of shelves, to about 200 c. c. of boiled water which had cooled; the mixture was shaken, the heaviest particles of dust allowed to settle, and the rest poured off. At the end of a few days this fluid contained active Vibrios.

Series III, consisted of six flasks containing the same as those of series I, sealed at the temperature of the room, and then boiled 30 minutes.

Series IV, consisting of six flasks, contained the same fluid

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with the addition of one drop of dust water to each flask; all were boiled 30 minutes.

On the second day one of series I, and all those of II were turbid and had a film—III and IV were unchanged, and perfectly transparent. On the third day infusoria appeared in III and IV, but were confined to the surface, forming a granular looking film, the fluid remaining transparent.

The contents of the flasks were examined with the microscope. I and II contained Vibrois of a large size, some of them extending nearly across the field, and when free moved slowly. III and IV also contained Vibrios, but of a very minute size and moved with great rapidity.

The boiling in the above experiment was followed by a later appearance of infusoria in III and IV than in I and II. The addition of dust water to series II, hastened the development of infusoria. In series IV to which the same dust had been added, but the flask and contents subsequently boiled after being sealed, infusoria appeared one day later.

Conclusions.—The following conclusions appear to the writer to be justified by the observations and experiments recorded in this paper.

1st. In thermal waters plants belonging to the lower kinds of Algæ live in water the temperature of which in some instances rises as high as 208° F.

2d. Solutions of organic matter boiled for twenty-five minutes, and exposed only to air which had passed through iron tubes heated to redness, became the seat of infusorial life. Exps. I–V.

3d. Similar solutions contained in flasks hermetically sealed, and then immersed in boiling water for periods varying from a few minutes to four hours, also became the seat of infusorial life. The infusoria were chiefly Vibrios, Bacteriums and Monads. Exps. VI–XV.

4th. No ciliated infusoria, unless Monads are such, appeared in the experiments referred to in the above conclusions.

5th. No infusoria of any kind appeared if the boiling was prolonged beyond a period of five hours.

6. Infusoria having the faculty of locomotion lost this when exposed in water to a temperature of from 120° to 134° F. Exp. page 172.

7. If Vibrios, Bacteriums and Monads are added to a clear and limpid organic solution, this becomes turbid from their multiplication in from one to two days. If however they have been previously boiled, the solution does not become turbid, until from one to two days later, and in some of the experiments not sooner than does the same solution to which no infusoria have been added.

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ART. XVI.—*Remarks on Prof. Geinitz's views respecting the Upper Paleozoic rocks and Fossils of Southeastern Nebraska;* by F. B. MEEK.

THROUGH the politeness of Prof. Geinitz, I have received a copy of his interesting and accurately illustrated work on the Upper Paleozoic rocks and fossils of southeastern Nebraska.* The numerous excellent figures he has here given, of many of our fossils not previously illustrated, will certainly be a great assistance to students, and place them under many obligations to the distinguished author. Being very reluctantly compelled to differ widely from him, however, in regard to many of his identifications and interpretations of these fossils, and feeling it to be a duty to correct errors into which he has fallen, it is but fair to first explain the difficulties with which he had to contend in entering upon this investigation. In the first place, he was, to a great extent, unacquainted with the Coal-measure fossils of this country, and wholly unprepared to understand and appreciate the remarkable mingling here of Coal-measure and Permian types and the frequent alternation of beds containing these two types of fossils, through a considerable thickness of strata. In addition to this, he was necessarily compelled to identify, and form all his conclusions respecting, a number of species described in this country, from descriptions alone, unaccompanied by illustrations; while the collections were submitted to him with erroneous views respecting the relations of the beds from which they were obtained, to the Coal-measures of that region.

It is also proper to further explain, for the information of general readers not familiar with Natural History, that differences of opinion in regard to such matters often arise from the fact that there are two schools of observers amongst paleontologists, as well as amongst investigators in recent zoology. Those of one of these schools give a very wide latitude to genera and species, while those of the other restrict both within more precise limits. That is to say, the first often include in a single genus types which those of the other school distribute into two or more genera, or in some cases, refer even to distinct families. Upon the same principles, those of the first school often regard as mere varieties or unimportant modifications of the same species (if they notice the differences at all) forms that the others consider specifically distinct. As might be expected, these different views respecting the value and importance of distinctive characters sometimes lead to very different conclusions, not

* Carbonformation und Dyas in Nebraska, von Dr. H. B. Geinitz, M. d. k. L-c. A. d. N. Dresden, 1866.

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only in regard to the geographical range of living animals, but also amongst paleontologists, in regard to the geological range, and duration in time, of extinct species and genera; and, as a consequence, respecting the ages and relations of formations. It is proper to add here, however, that the developments of modern zoology are constantly forcing upon our attention the absolute necessity for closer and closer attention to less striking differences in distinguishing genera and species, before we can hope to arrive at reliable conclusions in paleontology.

When it is understood that, out of a list of about ninety species of fossils enumerated by Prof. Geinitz from the beds in Kansas and Nebraska which he regards as belonging in part to the Carboniferous, and in part to the Permian, he identifies about fifty of these species with European, and in part East Indian forms, it will be readily understood by any one familiar with our fossils, that he must be one of those who admit very great diversities of characters as being consistent with specific identity. But before entering upon the discussion of differences of opinion respecting species, it may be well to mention some of the cases where we differ in regard to genera.

First the impropriety of referring to the genus *Turbonilla*, founded upon very small recent shells, ornamented with regular longitudinal costæ, and provided with a *sinistral apex*, shells with only revolving costæ, and a non-reversed apex, such as his *T. Swallowiana*, although not unfrequently done by other paleontologists, must be obvious to those familiar with living Mollusks. That these shells have not a sinistral apex, is well known to the writer, from careful examinations of several allied species from the Coal-measures of Illinois, in which the spire could be traced by the aid of a magnifier, to a minute point, without showing the slightest indications of a reversed apex.* To those unaccustomed to give attention to such characters, this may seem to be an insignificant distinction, but every well informed conchologist is aware that it is found to be coexistent amongst recent shells, with important differences in the anatomy of the animals inhabiting them. For the same reason, as well as on account of their generally much larger size, we may question the propriety of referring *any* of the paleozoic shells often described by paleontologists under the name *Chemnitzia*, and *Loxonema*, to the existing genus *Turbonilla*.

Again we have good reason for believing Prof. Geinitz is far from right in referring the common Coal-measure shell *Euompha-*

* One of the little shells here alluded to, was described by Dr. Stevens from the Coal-measures of Illinois under the name *Aclis minuta* (this Jour. II, xxv, p. 259); and another by Mr. Worthen and the writer from the same horizon, as *Turritella?? Stevensana* (Geol. Report Ill., ii, p. 382). It is quite improbable that they belong either to the genus *Aclis* or *Turritella*, but they are certainly not Turbonillas.

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lus rugosus Hall (not Sowerby), to the articulate genus *Spirorbis.* This shell is probably not a *Euomphalus*, but seems to be more nearly allied to the *Molluscan* genus *Bifrontia.* At any rate, of the thousands of specimens that have been found weathered out of the coal shales of the west, not a single one, so far as known to the writer, has ever been seen attached by the substance of even the first whorl of the shell to any other body; nor are we aware that any scar of attachment has ever been observed on either side of the shell, although they have been frequently examined under a magnifier with the view of determining this very question, in numerous perfect examples, entirely free from the matrix, and showing clearly all the volutions on both sides to the very center.

Nor is Prof. Geinitz's reference of his little *Murchisonia subtæniata*, to that genus, or *family* even admissible. It belongs on the contrary, to the genus *Orthonema* M. & W. (Ill. Report, vol. ii, pl. 31, f. 14), a group of small shells resembling *Murchisonia* in form and revolving markings, but differing in being *entirely without the slit or sinus in the lip* characterizing that whole family of shells. Prof. Geinitz did not see a sinus in the lip of his specimen, nor the corresponding revolving band, but thought a flattened space between two little revolving ridges might be a band, though he acknowledges that this view would indicate a proportionally wide flat band. In order to settle this point, however, an excellent specimen of the species *subtæniata*, was borrowed from Dr. White, the state geologist of Iowa, obtained from exactly the same horizon in the western part of that state, and on examining this by a cross light, under a good magnifier, its lines of growth were seen passing straight across the whorls, without making the slightest flexure such as we see in *Murchisonia* and other genera provided with a sinus in the lip. Several allied species of this genus are known in the Coal-measures of Illinois.

His reference of such shells as the so-called *Modiola squamosa* and *M. acuminata* of Sowerby (as illustrated in Prof. King's Perm. Foss.), to the genus *Aucella*, is also believed to be done on questionable grounds. The genus *Aucella*, it will be remembered, was founded by Count Keyserling, upon a group of Jurassic shells, differing from those mentioned above, not only in wanting their broad cardinal area, marked with linear parallel cartilage furrows, but also in possessing a little abruptly projecting anterior ear, defined in the right valve by a deeply impressed linear furrow extending from the beak to the margin, and terminating there in a sharply cut byssal emargination. Now on examining Prof. King's excellent figures of testiferous examples of the English shells mentioned above, it will be seen that they show no traces whatever, of this little anterior ear, though his

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figures of internal casts illustrate clearly the broad furrowed cardinal area of *Myalina*, to which genus these shells appear to belong.

It is true Prof. King's figures respecting *internal casts* of these shells, show a little projection between the beaks (as do some of our American species of *Myalina*), that might be mistaken for little ears,* but it is easy to see from perfect specimens showing that outside of the anterior margins of the shell, that these are not external ears, but the casts of a little cavity upon a kind of shelf or septum in the beaks, as stated by Prof. King. Prof. de Koninck mentions this little shelf and its concavity, in describing the genus *Myalina*; and although a more or less variable character, sometimes even in different individuals of the same species, evidences of its existence can generally be seen in the different species of that genus.

Prof. Geinitz has figured in his valuable work "Dyas" under the name *Aucella Hausmanni* (of which he regards the English species *squamosa* and *acuminata* synonyms), German examples of a shell that show, in one of the figures, some indications of a little anterior ear; but if it is really such, and not due to the accidental compression of the valves, as its absence in his other figures indicate, and the shell otherwise agrees with *Aucella*, we may well question its identity with the English forms mentioned above. It is also worthy of note, that Goldfuss's figures of the type of his species *Hausmanni* show no traces whatever of such ears. These shells sometimes have a slight prominence of the anterior margins of the valves, as we see in *Modiola*, but as we know by examining numerous examples of the allied American forms, there is never a defined ear, or sinus, but on the contrary, the margins of the valves fit closely there, and round up to the extremity of the hinge exactly as in *Modiola*.

Another mingling of distinct types under one generic name, is Prof. Geinitz's reference of such shells as the so-called *Monotis speluncaria*, and *Pinna prisca*, to the genus *Avicula*. The first of these types, it will be remembered, is exceedingly unlike the recent shells upon which the genus *Avicula* was founded; being nearly circular, plano-convex shells, with scarcely any perceptible obliquity, and almost destitute of proper alations at either extremity of the hinge. These and other differences led Prof. King to separate the species *speluncaria*, from the genus *Avicula*, and to place it provisionally in the genus *Monotis* Bronn, in which he has, until recently, been generally followed, both in this country and in Europe. On comparing the American

* A precisely similar cavity exists between the beaks of *Amphicœlia*, Hall, from the Upper Silurian; and internal casts of these look very much like little ears, which the writer at one time supposed them to be; but good specimens of the shell preserving perfectly the anterior margins of the valves, show clearly that there is no external anterior ear whatever.

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shells of this type, in 1864, with authentic European examples of the type of Bronn's genus *Monotis* (*M. speluncaria* of the St. Cassian beds), the writer was led by the very nearly equivalve character, and entire *absence of any traces of a byssal emargination* in the latter, to regard these two forms as belonging to distinct genera, and consequently to propose for the *speluncaria* group, the name *Eumicrotis*,* not being at that time, nor until very recently, aware that Beyrich had nearly two years previously proposed to separate this group from *Monotis*, on precisely the same grounds, under the name *Pseudomonotis*.† Prof. Geinitz thinks that if this type should be separated at all from *Avicula*, it should be referred to *Aucella*, which was also sometime back suggested by Prof. McCoy. Although this would be more nearly correct than to refer such shells to *Avicula* or *Monotis*, a strictly systematic classification of all the various groups of the *Aviculidæ*, would forbid such an association.

If those who hold that a natural classification requires the separation of such forms as the genera *Cassianella*, *Pseudomonotis* and *Avicula*, surely they will very decidedly protest against the reference to the latter genus of such shells as the so-called *Pinna prisca* Münster, (=*Avicula pinnæformis* Geinitz).‡ Indeed it seems scarcely possible to conceive of two bivalves within the limits of the same family, more unlike than this and *Avicula*; almost the only character by which it can be distinguished generically from those slender, straight, elongated Carboniferous species of *Pinna*, being the position of its nearly obsolete beaks a little behind the rather pointed anterior extremity, instead of being terminal. Conchologists will readily understand how unlike *Avicula* it must be, when it is mentioned that Prof. Geinitz at one time even referred it to the genus *Solen*.

* This Jour., II, xxxvii, 216.

† The note of only about one page in which Beyrich proposed the name *Pseudomonotis* for this genus (Zeitschr. der Deutsch. geol. Gesellsch, xiv, p. 10), being unaccompanied with illustrations, or a conspicuous heading to distinguish it from other matter, had escaped the attention of the writer in preparing a classification of the *Aviculidæ*, or the name *Pseudomonotis* would have been adopted. In the same note Prof. Beyrich proposed another genus *Cassianella*, with the *Avicula gryphæata* of Münster as its type. For this, the writer, on the same grounds, proposed the name *Gryphorhynchus*, in 1864. Beyrich's names for both of these genera, however, having priority of date, will have to take precedence. Although neither of these genera would be admitted by those who give such wide limits to groups, it is manifest that such distinctions are attracting the attention of systematic workers everywhere. For instance, Laube adopts *Cassianella* as a good genus in his beautiful Monograph of the St. Cassian fossils recently published. He also there proposes, on apparently good characters, a genus *Hörnessia*, for a group of which the so-called *Gervillia socialis* of authors is the type; though it is probable this will prove to be a synonym of Mr. Gabb's genus *Rhynchopteris*, published in the California Report in 1864, and founded upon a shell presenting similar external characters, and from near the same horizon, in Nevada.

‡ For this type the writer proposed the name *Aviculopinna*, in 1864, (this Jour., vol. xxxvii, cited above.

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The propriety of referring the little Permian and Carboniferous shells for which Prof. King proposed the name *Bakevellia*, to the genus *Gervillea*, is, to say the least, very doubtful. Although these types are unquestionably closely related, the uniform smaller size of the species of the former group, the more nearly equal convexity of their valves, usually smaller number of cartilage cavities, and generally less elongated form in proportion to the length of the hinge line, are characters which, when viewed collectively, indicate generic differences. The most important distinction, however, is found in the hinge teeth, which although variable in both groups, differ in that those on the posterior side of *Bakevellia* are elongate, linear and directed parallel to the hinge line, instead of being shorter and oblique; while those in front of the beaks range obliquely forward and downward, instead of forward and upward, as in *Gervillea*. Again *Bakevellia* has the anterior muscular scar proportionally larger, so much so indeed that Prof. King referred the genus to the *Dimyaria*, though it belongs to the *Avicula* group near *Gervillia*.

Again, in including in the genus *Pecten* the Paleozoic shells for which Prof. McCoy proposed the name *Aviculopecten*, Prof. Geinitz ignores important distinctions that have been known for fifteen or sixteen years past, to clearly separate these groups. These are the proportionally larger size of the posterior ear in *Aviculopecten*, instead of the reverse, and its broad *Pterinea*-like cardinal area, or hinge plate, with parallel longitudinal cartilage furrows, and in general without traces of a central cartilage pit under the beaks. Even Woodward, who was the most extremely conservative of all modern conchologists, in regard to generic distinctions, not only separated these shells from the genus *Pecten*, but even placed them doubtfully in the family *Aviculidæ*. No well informed conchologist would at the present time refer to the genus *Pecten*, as properly restricted, any Paleozoic species.*

He is also behind the present state of conchological science in placing in the genus *Arca* forms like the so-called *A. striata* Schlot. (sp.), with the posterior hinge teeth linear, elongated and ranging parallel to the cardinal margin. These belong to the genus *Macrodon* of Morris and Lycett. Even Woodward separates this group from *Arca*, but without sufficient reason includes it as a subgenus under *Cucullæa*. There are no true Arcas in the Paleozoic rocks.

Another unnatural mingling of distinct types is his reference of typical Ledas (properly *Nuculana*,) to the genus *Nucula*.

* Prof. Agassiz, who has gone over the whole family *Pectenidæ* with great care, and his usual thoroughness, does not, if correctly understood by the writer, refer *any* of the fossil species from older rocks than the Tertiary, to the genus *Pecten*, as properly restricted.

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Woodward, Carpenter, Gray, H. & A. Adams, Deshayes, Chenu, in short, all good conchologists admit this as a distinct *genus* from *Nucula;* while Carpenter, H. & A. Adams, Mörch, and other late systematic writers, separate it as the type of a distinct *family* from the *Nuculidæ.*

But the most unaccountable error into which Prof. Geinitz has fallen, is in placing in the genus *Rhynchonella*, *Spirifer hemiplicatus* of Hall, the type of the new genus *Syntrilasma*, Meek & Worthen (Ill. Geol. Report, ii, 321). Being a somewhat peculiar shell, if the cardinal region of the valves was hidden in the matrix, and the surface striæ somewhat obscured, it might be mistaken for a *Rhynchonella;* but the most surprising thing is that he should have referred it to that genus, when the very specimens figured by him show it to have a straight hinge line, and a well defined cardinal area,* divided in the ventral valve by a triangular open fissure, while another figure shows it to have in the dorsal valve, the crura and *cardinal process*, as in *Orthis.* The fact is, this shell does not even belong to the *Rhynchonellidæ*, as its punctate structure and other characters show. The fact that Prof. Geinitz, after referring it to *Rhynchonella*, speaks of it as "this rare and beautiful *Terebratula*," would also seem to indicate that he does not even regard the distinctions between these two genera (well known to be the types of two distinct families), of much consequence.

Again Prof. Geinitz overlooks important distinguishing characters, when he refers (without even a recognition as a subgenus) to the genus *Orthis*, a typical *Streptorhynchus* (properly *Hemipronites*). The distinctions between these types are well defined, so much so that even Mr. Davidson, who is always cautious and conservative in admitting even subgenera, considers it a good subgenus; while most of the highest authorities in various departments of recent zoology view differences of no greater importance as being of full generic value.

Any of the numerous collectors of western Coal-measure fossils will at once recognize the spines figured by Prof. Geinitz (pl. iv, fig. 29), and referred by him to *Actinocrinus*, as those of *Zeacrinus mucrospinus* McChesney. These spines, probably belonging to two or more allied species, are widely distributed in our Coal-measures, from West Virginia and Pennsylvania, to

* It is scarcely necessary to explain here that when Prof. de Koninck speaks of an area, in describing *Rhynchonella angulata* Linn (to which species Prof. Geinitz refers the shell under consideration), he alludes to a flattened oval space on each side of the shell, converging to the beaks at an angle of about ninety degrees, and not to a true cardinal area, such as that term is applied to in describing Brachiopods generally. If any one, however, has any doubts on this point, these will at once be removed by turning to Mr. Davidson's excellent figures and description of *R. angulata* (Monogr. Brit. Carb. Brach., p. xix), prepared after a careful study of Linnæus's original specimen.

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Nebraska, and southward to Texas and New Mexico; while they may be at a glance distinguished from those of any of the forms usually referred to *Actinocrinus*. They belong indeed to different parts of the crinoid, being modified second radial pieces, while those of *A. cornigerous*, and *A. Gouldi*, with which Prof. Geinitz compares them, are modified vault-pieces, that rise obliquely upward out of the vault from above the horizon of the arms. This difference in the position and relations to the other parts, of these spines, imparts an entirely different form to the head or larger extremity, from those of any of the Sub-carboniferous crinoids, that renders it very easy to distinguish them. It is unnecessary to inform any one acquainted with western fossils, that no species of *Actinocrinus*, even giving that genus its widest limits, has yet been found above the horizon of the St. Louis Limestone, of the Sub-carboniferous series, and the only two species found thus far up belong to the *Batocrinus* section.

Having thus pointed out what are believed to be errors in regard to generic references, respecting which students who may use Prof. Geinitz's work ought to be informed, some remarks on the specific relations of these fossils may not be out of place.

First a little planorbicular shell (fig. 6, pl. 1), referred by Prof. Geinitz to *Serpula* (*Spirorbis*) *planorbites* Münster, is certainly, as he suspected, the same figured and described by Prof. Hall from the Coal-measures of Illinois under the name *Euomphalus rugosus*, in the Iowa Report. The reasons, however, for not believing it to belong even to the same primary division of the Animal Kingdom as the genus *Spirorbis*, have already been stated. That it is also clearly distinct specifically from the European *S. planorbites*, even if they could be forced into the same genus, is more positively certain, as I know from a direct comparison with authentic foreign specimens of the latter.* Of the Nebraska shell I have numerous specimens before me, from various localities in that region, as well as from Kansas, western Iowa and from Illinois. On comparing these with German examples of *S. spirorbites*, they are easily distinguished by having the whorls always *very distinctly* quadrangular, and broadly flattened on the outer side, instead of presenting an oval section with a rounded or subangular dorsal side as in the German species. The latter also has its deepest umbilical concavity on the left side (placing the shell with the mouth turned downward and away from the observer), instead of the reverse. Prof. Geinitz had also observed that there is a shallow furrow around the middle of the side of the whorls in the Nebraska fossil, where there ought to be a prominence to make it correspond to the *S. spirorbites*, but thinks this is due to the accidental pressing inward of this prom-

* All the foreign specimens of Permian fossils alluded to in the paper belong to the Museum of the Smithsonian Institution.

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inence. This obscure furrow, however, is a natural character in the *E. rugosus*, though not always equally well defined, and sometimes becoming obsolete. Finally it attains a size of from four to six times that of the *spirorbites*. The latter, as shown by Prof. Geinitz's figures in his "Dyas," as well as by the specimens, varies considerably in some respects, but the American shell is *very* constant and regular in form, and in most of its characters.

I differ, if possible, still more decidedly from Prof. Geinitz, in thinking *Spirorbis helix* of King identical with this; and doubt the identity of King's species with the true *S. spirorbites*. If our shell is identical with any European species, it agrees most nearly with the Carboniferous species *Euomphalus carbonarius* Sowerby (=*E. quadratus* McCoy, Carb. Foss. Ireland, pl. 5, fig. 22), which it quite nearly resembles, though even these forms are clearly distinct.

Murchisonia subtæniata Geinitz, Carb. und Dyas, pl. 1, fig. 18. As already stated this is a true *Orthonema*, and will have to take the name *O. subtæniata*.

Bellerophon interlineatus Portlock. Geinitz, ib. This may or may not be identical with Portlock's species. At any rate it occurs in the Coal-measures of Kansas. The *B. carbonarius*, and *B. Montfortianus* N. & P. mentioned by Prof. Geinitz among other fossils from the beds he refers to the Dyas, are well-known Coal-measure species in the West. His *B. Marcouanus* seems to be a good new species.

Macrocheilus Hallianus Geinitz, ib., fig. 7. This probably belongs to the genus *Soleniscus* Meek & Worthen (Illinois Report, ii, pl. 31, fig. 15), as it presents much the appearance of specimens of the type of that genus with the beak and lower part of the outer lip broken away. If the specimen figured has had an *accidental* depression made on the columella above the fold, it may even be the typical species originally described from the Coal-measures of Illinois.

Allorisma elegans King. Geinitz, ib., f. 21. If we may judge from the published figures and descriptions of this species, there can be little room for doubting that the Nebraska shell figured under that name is a distinct species, even after making liberal allowances for variations. If so, it may be called *Allorisma? Geinitzi*, though it seems very doubtful whether it is a true *Allorisma*. It appears to be congeneric with, and allied specifically to, species described by Dr. Shumard from the Coal-measures of Kansas and Missouri, under the names *Leptodomus Topekaensis*, and *L. granosus*. It is probable that all these shells should be referred to the genus *Sedgwickia* of McCoy, as properly restricted to the types for which that name was first proposed (see Paleont. Upp. Missouri, p. 38).

Solenomya biarmica de Vern. Geinitz, ib. The specimen figured

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is too imperfect for satisfactory identification or to show any reliable characters for distinguishing it from forms in our Coal-measures.

Astarte gibbosa McCoy. Geinitz, ib., fig. 23. This agrees quite nearly with McCoy's figure, but to establish *positive* specific identity would require a comparison of specimens showing the hinge and interior, which *might* even show them to belong to different genera. They are probably both Edmondias, however, and look unlike *Astarte*. Dr. White finds them in the Upper Coal-measures of Iowa.

Astarte Nebrascensis (n. sp.), and *A. Mortonensis* Geinitz, ib., as well as the form he figures *A. Vallisnerianus* King, have more the aspect of *Astarte;* but the latter looks less like Prof. King's figures than the form figured as a new species *A. Nebrascensis*. At any rate, specific identifications, and even generic references of such shells, can be admitted only provisionally, until the hinge and interior is known.

Schizodus obscurus Sowerby, and *S. Rossicus* de Vern. The forms figured under these names on plate I, resemble these European shells quite nearly; but it must be obvious that in a genus like this, in which species vary more or less in outline, and present so few characters for identification, little reliance can be placed upon identifications from external characters only, especially when the specimens were obtained at so widely distant localities. The form referred to *S. obscurus* (figs. 30 and 31), looks more like Prof. King's figures of *S. Schlotheimi* Geinitz, as well as more like natural casts of that species now before me from Germany, than like Sowerby's or King's figures of *S. obscurus*, which shows more elevated, and more ventricose beaks. From a tracing of the type of Prof. Swallow's *Cypricardia? Wheeleri*, described from the Missouri Coal-measures, it appears almost certain that it is the same here figured under the name of *S. obscurus*. Young examples of *S. alpina* (=*Dolabra? alpina* Hall, Iowa Rep., pl. 29, f. 2) from the Lower Coal-measures, in some of its variations, rather nearly resemble the form referred by Prof. Geinitz to *R. Rossicus*, though that is doubtless a distinct species. Dr. White finds both of the shells figured by Prof. Geinitz near the middle of the Upper Coal-measures of Iowa.

Arca striata Schlot. Geinitz, ib., fig. 32. As already explained, the shell figured by Prof. Geinitz under this name is a true *Macrodon*. It is the same species described by Mr. Worthen and the writer (Proceed. Chicago Acad. Sci., i, p. 17) from the Coal-measures at Springfield, Illinois, under the name *M. tenuistriata*. It differs clearly from the European *M. striata*, however, of which I have good examples at hand for comparison, in having its radiating lines very much smaller, or reduced to minute obsolescent striæ on the middle and anterior half of the valves. The speci-

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men figured by Prof. Geinitz only retains the shell at the posterior end, where the striæ are stronger, and agree more nearly with those of the European form. Through the politeness of Dr. White, I have had an opportunity to compare good gutta-percha casts of the hinge of this shell, from the same horizon in western Iowa as the Nebraska City beds, and they agree well with the Illinois shell. I am aware that *M. striata* varies in the size of its striæ, but it never has them reduced to very minute or obsolete lines on the anterior part of the valves, like the American species, which is quite constant in this character. I agree with Prof. King and others in believing some of the European forms Prof. Geinitz thinks identical with the species *striata*, are specifically distinct.

Nucula Kazanensis de Vern. Geinitz, ib., f. 33–34. The figures of the species *Kazanensis*, originally published in the Geology of Russia, being merely from imperfect moulds left in the matrix, do not afford a reliable means for comparison, though they look like the Nebraska shell. Whatever may be its relations, however, to the *Kazanensis*, it will be readily recognized by those familiar with the western Coal-measure fossils, as the form described by Dr. Stevens from the Coal-measures of Illinois under the name *Leda bellistriata*. Of course it is not a *Nucula*.

Nucula Beyrichi Schloth. Geinitz, ib., 36 and 37. This has the form of a true *Nucula*, and agrees pretty well in form with Prof. Geinitz's figures of German examples of that species given in Prof. Geinitz's "Dyas," but less nearly with specimens sent from Germany under that name. They are probably the same described by McChesney from the Coal-measures under the name *N. parva*.

Clidophorus Pallasi M. V. & K.* Geinitz, ib., pl. II, fig. 3, (fig. 4 appears to represent some other shell.) This figure was evidently made from the internal cast of a shell very near, if not identical with, *Pleurophorus occidentalis* Meek & Hayden, to which *genus* at least it certainly belongs. It may, or may not be, identical with some of the German shells referred to the Russian species *Pallasi*; but if we are to be guided in regard to the true characters of the type of that species by the figures and description published by its founders in the Geology of Russia, the Nebraska shell, which is shown to have the posterior hinge-teeth at least of *Pleurophorus*, must be a very different type, since the Russian species is both figured and described as being "*completely edentulous*." The Russian species is therefore not a *Pleurophorus* (= *Clidophorus*) at all, but is more probably, as suggested

* If *Pleurophorus* and *Clidophorus* are synonyms, or only sections of the same genus, it is *Pleurophorus* and not *Clidophorus*, as Prof. Geinitz seems to think, that must take precedence, as King proposed the former genus, naming the so-called *Arca costata*, as its type, in 1844, while *Clidophorus* was not published by Prof. Hall until 1847.

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by Prof. King, a *Cardiomorpha*. It also differs from the Nebraska shell in having the internal ridge bounding the anterior muscular scar (as shown in the figures and mentioned in the description) ranging obliquely backward and downward at an angle of 45° to the axis of the valves, instead of nearly at right angles to the same, as shown in the figure of the Nebraska species.

I have now before me an internal cast, and a specimen showing the exterior, of what are strongly suspected to be two very distinct types, that came from Germany with the name *Clidophorus Pallasi* attached. The one showing the exterior agrees quite well with some of Prof. King's figures of his *Cardiomorpha modioliformis*, which Prof. Geinitz cites as a synonym of the Russian species *Pallasi;* but the other specimen, that is, the internal cast, shows that *it*, at least, is a true *Pleurophorus*, as it has a hinge with teeth like the Nebraska shell; while one of Prof. King's figures of a cast and his description show that his *modioliformis* is edentulous, like the species *Pallasi*.

From these facts, it seems highly probable that two types are, at any rate sometimes, confounded in Germany, under the name *C. Pallasi*;* that is, one edentulous, agreeing perhaps specifically with Prof. King's *modioliformis*, and another with a toothed hinge, or in other words a true *Pleurophorus*. If the Nebraska shell belongs to any European species, it is far more probable that it is identical with *Pleurophorus costatus*, with casts of which, now before me from Europe, Prof. Geinitz's figure closely agrees.

Clidophorus (*Pleurophorus*) *occidentalis* M. & H. Geinitz, ib., tab. ii, fig. 6. The shell figured under this name is certainly not the *P. occidentalis* Meek & Hayden. In that species, the beaks are, as described, narrow and projecting beyond the termination of the hinge, being in fact nearly or quite terminal, while its dorsal outline is straight or even a little concave from the beaks posteriorly. The form figured by Prof. Geinitz is, so far as known to the writer, new, and may be called *Pleurophorus subellipticus*.

Cl. (*Pleurophorus*) *simplus* von Keyserling. Geinitz, ib., fig. 5. Prof. Geinitz did not have specimens of this shell from Nebraska, but gives a figure copied from Dana's Geology of a specimen from the Permian rocks of Kansas. It is the *P. subcuneatus* M. & H., and occurs both in the Permian and Permo-carboniferous beds. It varies considerably in form, and some of the varieties like that figured in Prof. Dana's Geology resemble *P. simplus*, though among all of the hundreds of examples I have seen, not one is proportionally so slender and elongated as the figure of the Russian shell. Nor have any of them the posterior hinge-teeth prolonged nearly so far backward.

Clidophorus solenoides Geinitz, ib., fig. 7. This is a good species of genus ?

* Prof. King says Prof. Geinitz formerly confounded *Pleurophorus costatus* with the edentulous so-called *Mytilus Pallasi*.

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Aucella Hausmanni Goldf. Geinitz, ib., fig. 8. This is doubtless a *Myalina* resembling the *M. squamosa* of England, but it is less nearly like *M. Hausmanni*, as figured by Goldfuss, and quite unlike Prof. Geinitz's figures of German specimens referred to that species. It is doubtless the same as *Myalina Swallovi* of McChesney, from the Missouri Coal-measures. I have also seen a similar form from beds in Nova Scotia, referred by good authorities to the Sub-carboniferous.

Mytilus concavus? Swallow. Geinitz, ib., fig. 9. This is not the form described by Prof. Swallow, which has angular instead of rounded umbonal slopes. It may be a *Myalina* but it is *certainly* not a true *Mytilus*.

Myalina perattenuata M. & H. Geinitz, ib., fig. 10–11. Correctly identified, but it is specifically distinct from *M. permiana* Swallow (cited by Geinitz as synonym), which has less attenuated beaks.

Myalina subquadrata Shumard. Geinitz, ib., figs. 25 and 26. Correctly identified. It is common in the upper Coal-measures of this region, and has been found by Dr. White in the same horizon in Iowa.

Avicula speluncaria Schlot. Geinitz, ib., fig. 12. As already stated, this belongs to Beyrich's genus *Pseudomonotis*. The specimen figured by Prof. Geinitz is not from Nebraska, but was sent to him by Prof. Dana from the Permian beds of Kansas, and is the same shell described by Dr. Hayden and the writer under the name *Monotis Hawni*.* It nearly resembles the European species *speluncaria*, and may *possibly* be identical, but good European specimens of that species now before me can be distinguished from the American form. At any rate we have a specimen from a bed of nearly black limestone, far down in the Coal-measures at Leavenworth, Kansas, agreeing even more nearly with *P. speluncaria* than *P. Hawni* does. Similar forms occur at different horizons in the Coal-measures and Permo-carboniferous beds in Kansas, and have been found in the Upper Coal-measures of Iowa, by Dr. White.

Avicula pinnæformis Geinitz, ib., fig. 13. From specimens of this shell shown to me by Dr. White from the same horizon in Iowa, I am sure it is specifically distinct from the so-called *A. pinnæformis*, and there can be little doubt that it even belongs to the distinct genus *Pinna*.

Gervillia parva M. & H. Geinitz, ib., 14. This differs from the *Bakevellia parva* M. & H. in having a broad shallow depression extending to the anterior basal margin from the umbonal region, farther back than that defining the anterior ear from the

* The species *Hawni*, will have to take the name *Pseudomonotis Hawni*, and the Illinois shell, supposed to be a variety of the same but probably distinct, may be called *P. sinuata*. (See Ill. Geol. Report, ii, pl. 27, fig. 12–13.)

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swell of the umbo in *B. parva.* It is an interesting fact, however, that there is a little shell, of which we have specimens for comparison, in the Nova Scotia beds, referred by the highest authorities to the Sub-carboniferous, agreeing with it in this character as well as apparently exactly in all other respects.

Gervillia longa Geinitz, ib., ii, fig. 15. A good species, but its position in the genus *Gervillia* is very doubtful. It occurs in Iowa, in a bed referred by Dr. White to the upper part of the Lower Coal-measures, with other fossils of that horizon.

G. (*Avicula*) *sulcata* Geinitz, ib., fig. 16. Also a good species.

Pecten neglectus Geinitz, ib., fig. 17. Appears to be a good species, but should be called *Aviculopecten neglectus.*

Pecten Missouriensis? Shumard. Geinitz, ib., fig. 18. This is certainly not the *Aviculopecten Missouriensis* of Shumard, which is not known from any horizon above the St. Louis limestone of the Sub-carboniferous series. It is the shell called *P. occidentalis* by Dr. Shumard, and afterward named *P. Cleavelandicus* by Prof. Swallow. It is one of the most widely distributed of our Coal-measure shells throughout the West, and ranges up through the Permo-carboniferous beds into the Permian of Kansas. No form nearly allied to it has ever been found in the western Sub-carboniferous rocks, but specimens now before me from rocks in Nova Scotia, so referred by the most reliable authorities, seem to be undistinguishable from it.

Pecten Hawni Geinitz, ib., fig. 19. This seems to be quite similar to *Pecten Broadheadii* of Swallow, described from the Missouri Coal-measures. If distinct from that species it should be called *Aviculopecten Hawni,* unless it may possess internal characters showing it to be the type of an undescribed genus. Dr. White finds it in the upper beds of the Lower Coal-measures of central Iowa.

Rhynchonella angulata Linn. Geinitz, ib., tab. iii, fig. 1–4. As it has already been shown that the shell figured under this name is not a *Rhynchonella* at all, little need be said in regard to its *specific* relations to the European true *Rhynchonella angulata.* I hope, however, that I shall be excused for adding here, that the practice of positively identifying species from widely distant parts of the earth upon such merely superficial points of general resemblance, and thus complicating and vitiating all conclusions respecting the geographical and geological range of species, cannot be too carefully avoided.

Camarophoria globulina Phillips. Geinitz, ib., fig. 5. Of this shell I have numerous examples from the same position, as well as from other horizons of the Upper Coal-measures of Missouri, Kansas, Nebraska and Iowa. It has generally been referred to *Rhynchonella Uta* of Marcou, who has himself identified it with that species. On comparison with authentic European examples

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of *Camarophoria globulina* of Phillips, it is found to be very similar in external characters, but there is an insurmountable difficulty in the way of referring it to that species,—that is, because sections across the beaks, as well as internal casts, show it to be *a true Rhynchonella*?

Retzia Mormonii Marcou (sp.). Geinitz., ib., fig. 6. This is the species described by Dr. Shumard from the Coal-measures as *R. punctulifera*, and his name probably has priority. It is a very common Coal-measure and Permo-carboniferous form in the west. Prof. Marcou mentions finding it at Nebraska City associated in bed C of his section with the other species referred by him and Prof. Geinitz to the Dyas;* though Prof. Geinitz does not mention it among the Dyas fossils at all, but refers it to the Carboniferous, giving Plattsmouth as the locality. Prof. Geinitz makes the California *R. compressa* a synonym of this, but the reasons for doing so are not very apparent, the two shells being quite different; he might with more propriety make the *R. Mormonii* a synonym of the European species *R. radialis* Phillips.

Athyris subtilita Hall, a form generally referred to *A. planosulcata* Phillips, *Spirifer planoconvexus* Shumard, *S. cameratus* Morton, and *Streptorhynchus crenistria* (properly *Hemipronites crenistria*), the so-called *Orthisina Missouriana*, figured or mentioned by Prof. Geinitz from beds he refers in part to the Dyas, and in part to the Carboniferous, all occur together, with the *Rhynchonella Uta*, *Retzia Mormonii*, and all of the *Producti* mentioned by him, as well as *Fusulina cylindrica*, in the same or alternating beds of the Coal-measures and Permo-carboniferous beds in Kansas, while *Athyris subtilita* ranges up into the highest beds containing Permian types.

Prof. Geinitz makes Mr. Davidson's East Indian *Spirifer Moosakhaliensis* a synonym of *S. cameratus* Morton. In this, however, he is certainly mistaken. Out of all the thousands of specimens of *S. cameratus* found in our western Coal-measure and Permo-carboniferous rocks, not one shows the distinct regular concentric lamellæ seen on that species, while there are other differences not to be overlooked.

Spirifer laminosus McCoy. Geinitz, ib., fig. 19. . This is *positively* not *S. laminosus* McCoy, but merely a variety of *Spiriferina Kentucensis*, of Shumard. It agrees with *S. laminosus* in no specific character excepting the possession of regular laminæ of growth, *S. laminosus* having a high flat area like a *Cyrtia* (to which group Prof. McCoy referred it), and a broad rounded mesial fold and sinus without longitudinal plications. One of McCoy's figures of a distorted specimen seems to show a plication in the sinus, but it is only necessary to consult Mr. Davidson's excel-

* See Bull. Soc. Geol. France, t. xxi, p. 137, 1864.

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lent figures and description of this species in his Monograph of the British Carboniferous Brachiopoda, or Prof. McCoy's description in his British Paleozoic fossils, to be convinced that the two shells are totally distinct. Indeed they probably belong to distinct subgenera or genera, as the *S. Kentuckensis* seems to be punctate like *Spiriferina*.

He is probably right in making Prof. Swallow's so-called *Orthisina Missouriana* a synonym of *Plicatula striato-costata* Cox, which I had done some years since. Dr. White and Mr. St.John, however, have ascertained that it posesses some very extraordinary intermal characters, showing it to be typical of a new genus. Although this shell closely resembles Mr. Davidson's East Indian *Streptorhynchus pectinifera*, with which Prof. Geinitz thinks it identical, they must be specifically distinct, if Mr. Davidson's figure represents the striæ correctly as running parallel to the plications to the front margin, instead of converging toward the top of the plications near the front.

If Prof. Geinitz is correct in identifying the shell he refers, without figure or description, to *Productus horrescens* with *P. Rogersii*, it is the same described by Dr. Owen under the name *P. Nebrascensis*. Dr. Owen's figure gives a very incorrect idea of this shell, and would never be recognized as even representing an allied form, but the locality from which he obtained his specimens and his comparisons with *P. Humboldtii* d'Orbigny, led to the belief that his type was the same as the *Rogersii*. In order to settle this question I borrowed Dr. Owen's typical specimens, labelled by himself, from his brother, Prof. Richard Owen, and found it to be the common Coal-measure shell generally known in the west as *P. Rogersii*. Out of thousands of specimens of this species, showing the hinge and interior of both valves, examined under all conditions and of all ages, not one has ever been seen showing any traces whatever of the cardinal area and hinge-teeth of *Strophalosia*. In short it is a true *Productus* closely allied to *P. scabriculus*.

Productus cora, *P. semireticulatus*, *P. costatus*, *P. punctatus*, &c., mentioned but not figured by Prof. Geinitz, are doubtless the same Coal-measure forms usually so referred in the west, and ranging in part up into the Permo-carboniferous. That he figures under the name *P. Flemingii*, is the same Coal-measure and Permo-carboniferous shell described by Dr. Norwood as *P. Prattenianus* (as indicated by Prof. Geinitz), which is also closely allied to *P. æquicostatus* Shumard, though it is certainly not the *P. Calhounianus* Swallow, nor *P. Flemingii*, as Prof. G. thinks. The other shell he figures under the name *P. Koninckianus* de Verneuil, looks exceedingly unlike the figures of the type of that species, being more probably only a larger individual of the same he figures as *P. Flemingii*.

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Productus Cancrini de Vern. Geinitz, ib., iv, fig. 6. Whatever relations the shell here figured bears to German specimens identified with *P. Cancrini,* it certainly differs from the original Russian type of that species, both in its proportions and in the prominence of its beak. At any rate I know it to range far down in the Coal-measure rocks of Kansas, below the horizon of the beds referred by Marcou and Prof. Geinitz to the Mountain limestone.

Productus Orbignianus de Koninck. Geinitz, ib., figs. 8 to 11. Prof. Geinitz seems to be right in regarding this form as the same as *P. splendens* and *P. Wabashensis* N. & P. But Mr. Davidson, however, who ought to know, refers both of these, from specimens sent him from the typical localities, to the Carboniferous species *P. longispinus* Sowerby. The shell figured by Prof. Geinitz is widely distributed and very abundant in our Coal-measures, and in Kansas ranges up into the Permo-carboniferous.

Productus horridus Sow. Geinitz, ib., fig. 7. There is no room whatever, to doubt but this is a young individual of the last mentioned species. That shell varies much in the distinctness of its costæ, which are sometimes almost entirely obsolete on even adult shells, and in young examples like this they are often not indicated at all, as may be seen by examining the the umbo of mature specimens. If *P. horridus* was known to occur in these rocks, it might be thought *possible* that this might be its young, but under existing circumstances, (that species being unknown in America), it would certainly require a considerable stretch of imagination, to see in this little shell a species which at maturity attains nearly one hundred times its size.*

Chonetes mucronata M. & W. Geinitz, ib., tab. iv, figs. 12, 14. This is correctly identified; and his *C. glabra* (ib., figs. 15 to 18) seems to be a good species. Both of these species, however, range far below this horizon in Kansas and Nebraska, even below the horizon of the beds referred by Professors Marcou and Geinitz to the Subcarboniferous.

Cyathocrinus ramosus Schlot. Geinitz, ib., fig. 19. Is from a European specimen, and given for comparison with the next, to which, however, it has no near relations. *C. ramosus* has not yet been found in any of our rocks.

Cyathocrinus inflexus Geinitz, ib., fig. 20. This species was long since described by Dr. Shumard from the Coal-measures of Missouri, under the name *Poteriocrinus hemisphericus* (Acad. Sci. St. Louis, i, p. 221). It is widely distributed in the western Coal-measures. Several specimens of it are in the Illinois collection from different localities in that state; and it is now known

* Since this was written, I have had an opportunity to examine extensive collections obtained by the Nebraska geological survey in charge of Dr. Hayden, at Nebraska City and all the surrounding country, and can assert *positively* that the little shell here figured is the young of that referred by Prof. Geinitz to *P. Orbignianus.*

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to occur at Omaha, in the beds referred by Prof. Marcou to the Mountain limestone. The separate crinoid plate (fig. 27) given by Prof. Geinitz on the same plate, is a first radial piece of the same species as the above, or of *Erisocrinus*, it being impossible to distinguish this part of these *Crinoids* when found detached. The fig. 28 of same plate, evidently represents the subradial piece of the *C. hemisphericus* from the anal side, being truncated above for the reception of the first anal piece and strongly incurved below. The columns figured on this plate as *Actinocrinus*? probably belong to the same crinoid, or to *Zeacrinus mucrospinus* McChesney, the spines of which are figured there erroneously as those of an *Actinocrinus*. As already stated, no *Actinocrinus* has yet been found in this country above the St. Louis Limestone.

Eocidaris Hallianus Geinitz, ib., tab. v, fig. 1, is probably a good species, and correctly referred. The corals figured on the same plate and referred to *Cyathaxonia*, are very like Coal-measure species of the West. One of them may be the same described by McChesney from the Coal-measures of Illinois under the name *C. prolifera*. The *Fusulina* figured on the same plate as *F. cylindrica* and *F. depressa*, range through our whole Coal-measures, of Iowa, Missouri, Kansas and Nebraska, and far up into the Permo-carboniferous of Kansas.*

As the so-called *Fenestella elegantissima* Eich., *F. plebeja* McCoy, *F. virgosa* Eich., and *Polypora papillata* McCoy, figured on plate v, are all identified from fragments showing but the nonporiferous side, such identifications are of course not to be relied upon in determining the age of rocks.

Polypora marginata McCoy. Geinitz, ib., fig. 11. The poriferous surface of this looks very unlike McCoy's species.

Polypora biarmica von Keyserling. Geinitz, ib., fig. 13. If the figures of this, and the form described by Count Keyserling are even nearly correct, they are clearly distinct.

Synocladia virgulacea Phillips. Geinitz, ib., 14. Prof. Geinitz has correctly identified this with the type for which Prof. Swallow proposed the name *S. biserialis*. It differs, however, clearly from the *S. virgulacea*, in having a row of little short spines (not mere granules) along the middle of each longitudinal branch, between the two rows of pores, and *particularly* in having *but two* rows of pores, instead of from three to five. Prof. Geinitz's figure shows the nonporiferous side, but his artist (who deserves great credit for his accuracy) has well represented the impressions of the row of little spines along the middle of the poriferous side, in impressions left in the matrix.

(To be continued.)

* Since this was written, I have this fossil in abundance, and many of our other common Coal-measure forms, from Nebraska City, obtained *above* the horizon of the very beds from which the so-called Dyassic fossils were obtained.

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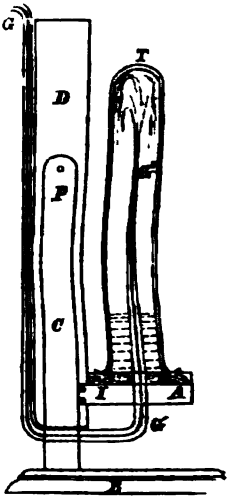
ART. XVII.—*Description of an apparatus for collecting and washing precipitates in test tubes;* by M. MCDONALD, Prof. Chem. Va. Military Institute.

THE apparatus is shown in the figure in side elevation. A is a bracket of hard wood or other suitable material, and serves as a support to the test tubes. It is firmly attached to the upright D which carries the inverted syphon tube G, G′, G″. It has a shoulder at I which abuts against the fixed support C and prevents oscillation.

Upon the bracket A rests the disk E of porous biscuit ware, and upon this, several thicknesses of filtering paper. The test tube T is adjusted as shown in the figure, and held firmly in place by a clamp (which is not shown). There is an orifice through the center of A and E through which passes the shorter branch of the inverted syphon tube G, G′, G″. This is drawn to a capillary bore at G″, and serves to introduce distilled water into the interior of the test tube for the purpose of washing the precipitate. The apparatus is supported upon the stand BC, and has a motion of rotation around the axis P.



The disks of filtering paper have a diameter slightly less than the diameter of the disk E; their centers are perforated with holes a little less in diameter than the syphon tube at the point F.

To use the instrument, several thicknesses of filtering paper are slipped over G″ and pressed evenly down upon E. The apparatus is then inverted in its frame, the test tube containing the precipitate adjusted and secured in position by the clamps and then restored to the position shown in the figure.

The syphon tube is then connected with the delivery tube of a wash bottle and a jet of distilled water thrown into the interior of the test tube.

Usually this jet may be projected against the bottom of the tube with sufficient force to wash all the precipitate down upon the filter. The test tube should fit very closely upon the support, or the pressure will force liquid and precipitate through together.

Modifications of the apparatus for special purposes will readily suggest themselves, and any one of ordinary ingenuity may construct one for himself.

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ART. XVIII.—*On certain Lecture Experiments, and on a new form of Eudiometer;* by JOSIAH P. COOKE, Jr.

THE laws of combination by volume fill such an important place in our modern chemical philosophy that simple methods of illustrating these fundamental principles in the lecture room are eagerly sought by every teacher of the science. The many new and interesting experiments devised for this purpose by Prof. Hofmann, first described in the Journal of the Chemical Society of London (Ser. II, vol. iii, page 156), and subsequently made still more widely known through his admirable "Introduction to Modern Chemistry," leave little to be desired so far as regards accuracy of results or elegance of illustration. But these experiments require for the most part a delicacy of manipulation, which is incompatible with the hurry of the lecture room, and a skill in glass-blowing which can rarely be attained or commanded by our American teachers. Hence while seeking the same end as Professor Hofmann, but with less ample appliances, the author has devised for his own lecture-room methods of illustrating the same principles, which require less delicate apparatus and less careful attention, although as analytical methods they may not always be as accurate as those of this eminent German chemist. Following also the recommendation of Prof. Hofmann in the article just referred to, the author publishes his methods with the hope that they may serve to bring the illustrations of these fundamental laws of chemistry within the reach of the great body of teachers in this country.

Many of the methods described in this paper are alone rendered possible by the application of vulcanized rubber stoppers in the construction of the required apparatus. Hitherto these have not been made of good quality in this country, and those imported from Europe were very costly, and could only be obtained of a few invariable sizes. At the suggestion of the author, the "Boston Belting Co." now manufacture an excellent article, which they call "stopper cord," consisting of conical rolls of very elastic rubber, about 4 feet in length and varying in diameter from one-half an inch at one end, to an inch and a half at the other.* From these rolls, stoppers of any required size between the limits named may be cut with an ordinary knife and bored with a common brass cork-borer. It is only necessary to moisten the tools with water in order to prevent the adhesion of the rubber. Stoppers of this material are absolutely air-tight

* After a good deal of experience, rolls of the sizes named above have been found to be the most universally applicable, but they can be made to order of any desired dimension and at a cost not exceeding one dollar a pound. See fig. 5, where one of these rolls is shown in the fore-ground of the wood cut.

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even against a full atmospheric pressure, provided that the surface of adhesion to the glass neck is at least half an inch in length.

Another material of prime importance in these experiments is sodium amalgam, which is most conveniently used when containing so large an amount of sodium as to form a hard solid. It is best prepared by gently heating a few ounces of metallic mercury in a shallow iron dish and then cautiously adding one-twentieth of its weight of sodium. The first half of the sodium should be added in very small portions at a time as the action at the beginning is exceedingly violent, but soon moderates, and at last the melted amalgam must be stirred with an iron spatula in order to incorporate thoroughly the materials. As soon as cold the solid amalgam readily separates from the dish, and should then at once be broken up into small fragments and preserved in a well stoppered bottle.

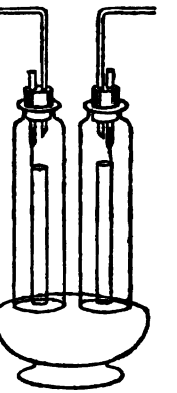
The four great typical compounds of modern chemistry are HCl, H_2O, H_3N and H_4C. Excepting the last, for which we have no new methods, we will now describe our methods of illustrating the composition of each of these in turn.

Hydrochloric acid.—The points to be illustrated in the case of this gas are all indicated by the equation $\boxed{H} + \boxed{Cl} = \boxed{HCl}$ or by the molecular expression

$$\boxed{HH} + \boxed{ClCl} = \boxed{HCl}\,\boxed{HCl}$$

The first fact that HCl consists of hydrogen and chlorine gases we prove by the electrolysis of strong liquid hydrochloric acid, having previously shown in the course of the lecture how HCl is obtained from common salt, and that the liquid acid is merely a solution of the gas in water. The decomposing cell, which we use in this experiment, is represented in outline by fig. 1, which is drawn to a scale of $\frac{1}{3}$, so that both its construction and dimensions require no detailed description. The two small open glass cylinders are fitted by grinding with emery to the two tubulatures of the cell, and when the instrument is not in use are closed above with ground glass stoppers. When mounted for use the cell is filled with strong hydrochloric acid to within an inch of the upper mouths of the cylinders, and the glass stoppers are replaced by rubber stoppers, through which pass the gas delivery tubes and the conducting wires connecting with the electrodes, which are two strips of platinum foil four inches long by

1.



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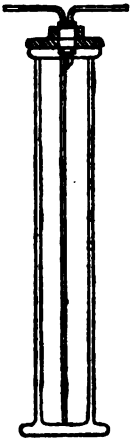
one inch wide. The platinum conducting wires are welded* to the strips of foil and secured in the rubber stoppers as represented in detail by fig. 2. Into the lower end of a short piece of glass tube, which passes tightly through the rubber, the platinum wire connecting with the foil is secured by melting the glass around it, while the upper end is left open to receive the copper conducting wires from the battery, and the connection is made perfect by placing a few drops of mercury in the tube. This simple form of connecting-cup is easily made and very convenient.

2.

As the conducting power of hydrochloric acid is very good, three Bunsen cells of the ordinary size have ample intensity and give a rapid evolution of gas. The hydrogen gas is conducted into a tall but narrow glass jar mounted in the usual way over a small pneumatic trough, while the chlorine is collected by displacement in a precisely similar jar mounted as represented in fig. 3. The mouth of this jar is closed by a ground glass plate, which is tubulated, as is shown in detail by fig. 4. This tubulature again is closed by a rubber stopper, through which pass first, the delivery tube, which reaches the bottom of the jar, and secondly an overflow tube which merely passes through the stopper, and which in the experiment should be connected by a flexible hose with a ventilator. When a larger amount of chlorine is desired the first jar may be connected with a second, and that with a third, etc., all mounted in the same way, and the exit tube from the last jar leading to a ventilator as before. When the jars are full the tubulated stoppers with their connections are removed and a plain glass cover substituted. This simple form of apparatus will be found very useful in all experiments on gases heavier than the air.

3.



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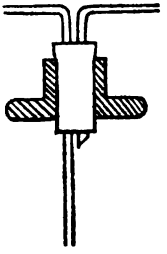

During the process of electrolysis the class will see that the two gases are evolved in nearly the same proportions, the colored gas rising in one jar as rapidly as the water falls in the other. The narrowness of the jar prevents to a great degree the diffusion of the chlorine, and a piece of white paper placed

* The platinum wire is very easily welded to the foil on a smoothed surface of a lump of quick lime which serves as an anvil. The two having been placed together in the required position on this support are first intensely heated at the points to be united, with a blow-pipe flame, and then a quick blow with a small hammer completes the work.

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behind the jar, will make the line between the colored gas and the air visible to a considerable distance. When the jars are full, the qualities of the two gases may be made evident by appropriate experiments. As is well known, the gases will not be delivered in atomic proportions, until the liquid acid is saturated with chlorine. It is best therefore not to empty the cell after the experiments, but, having removed the rubber stoppers with their attachments, to close the mouth with the ground glass stoppers, and the apparatus will then be ready for the next occasion. It is also best to interpose a small wash bottle containing sulphuric acid, between the cell and the chlorine jar, for this will not only dry the gas but also equalize the hydrostatic pressure on the two delivery tubes. Decomposing cells like that represented in fig. 1, and all other forms of glassware described in this paper are made by the New England Glass Co., of East Cambridge, and can be ordered through any of the dealers in philosophical apparatus in Boston. A much simpler decomposing cell, although not quite so efficient an apparatus, can be made with a common U tube supported on a wooden stand and mounted with rubber stoppers, delivery tubes and platinum electrodes in every respect like the other.

The second point to be illustrated in regard to hydrochloric acid is, that it consists of equal volumes of its constituent gases; and although by our first experiment, if made in the way we have described, it is shown that the gases are evolved in nearly equal proportions, yet a second experiment is required to establish the absolute truth* of this important fact. The apparatus we use for this purpose is represented in fig. 5, and the details of the several parts are shown in fig. 6. The two gases are evolved together from a simple decomposing cell, shown more in detail in fig. 9, but in connection with another apparatus, and the connection of the battery with the two electrodes, is here made as before shown in fig. 2. The mixed gases pass through a small drying tube filled with pumice moistened with oil of vitriol, into an absorption tube whose construction is shown in detail by fig. 6. As the gaseous mixture is decidedly lighter than air, it is conducted to the top of the absorption tube through the small quill tube, and overflows through the short tube below. Both of these should pass air-tight through the rubber stopper, which closes the mouth of the large absorption tube and

* We here of course leave out of view the small difference which arises from the fact that the gases do not absolutely obey Mariotte's law and are therefore unequally condensed even by the atmospheric pressure. The volumes of the two gases would undoubtedly be exactly equal under greatly diminished pressure, but under the pressure of the air, the volume of the molecular weight of chlorine is about $\frac{1}{100}$ less than the corresponding volume of the molecular weight of hydrogen, a difference by no means inappreciable in accurate experiments.

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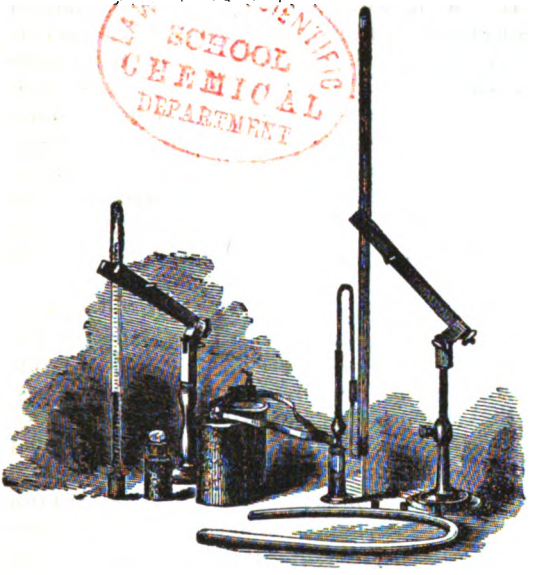
which should therefore have a bearing on the glass of at least half an inch. It will be noticed that while the overflow tube

5.



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6.

is straight, the delivery tube is bent so that its open end is four or five inches above the mouth of the absorption tube. Rubber stoppers, or rather caps, must also be provided, by which the open ends both of the delivery and the overflow tubes may be closed at the right time. These are made by boring with a cork-borer *nearly* through an ordinary stopper and then pulling out the rubber core with a pair of pincers. The absorption tube should now be divided into two parts of equal capacity by means of rubber rings having however a length of three or four inches at the lower end for the absorbent liquid.

The absorption tube having been prepared as described and filled with the mixed gases, the experiment is made in the following way. The apparatus is first rapidly depressed in a solution of caustic soda (of the ordinary strength used in the laboratory) until the liquid rises in the tube to the level of the first ring. The open end of the delivery tube is now quickly closed with the rubber cap, and then the end of the overflow tube is closed in the same way—the second rubber cap having been previously dropped upon the bottom of the glass vessel containing the soda solution so as to be ready for the purpose. The tube, now perfectly air tight, is removed from the liquid and the solu-

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tion of soda turned backward and forward through its entire length until the chlorine is wholly absorbed. The end of the overflow tube is now opened under water colored blue with litmus, which, as it rushes in, will be instantaneously bleached, indicating the presence of chlorine. The tube must now be immersed in the water until the level of the liquid is the same within and without, when it will be found that just one-half of the gas has been absorbed. We have now proved that one-half of the volume of gas evolved during the electrolysis of hydrochloric acid consists of chlorine, and it only remains to show that the remaining half still left in the tube is hydrogen. For this purpose the delivery tube may be connected with a water faucet and the gas burnt as it is forced out through the overflow tube.

We have now proved first, that hydrochloric acid is composed of hydrogen and chlorine; secondly, that these gases are present in equal proportions by volume, and in order to complete our demonstration of the constitution of this typical compound, we have only to prove that when these equal volumes unite to form HCl there is no condensation. This we may do either synthetically or analytically.

The synthetical experiment is made by filling the absorption tube as before with the mixed gases obtained by the electrolysis of hydrochloric acid, taking great care, as also in the previous experiment, that the tube should be perfectly dry. It will of course be necessary to have two of these tubes if both experiments are to be made in the same lecture. The tube thus filled is to be exposed for some time to bright diffused sun-light, and afterwards directly to the sun-beam until perfect combination results. If the glass is quite thick, and the rubber stopper is forced in very tight, the gases may even be exploded in the tube without danger, although this form of the experiment is always attended with some risk. When the gases are in either way thoroughly combined, the end of the exit tube is first opened under mercury, in order to prove that no condensation has taken place, and afterwards under water colored blue by litmus, when a very rapid absorption takes place, and the reddening of the water will indicate that HCl has in fact been formed.

The analytical experiment is made by decomposing HCl gas by means of sodium amalgam. For this purpose the carefully dried gas is first collected over mercury in a perfectly dry tube. This tube we assume is graduated, or at least divided into two parts of equal capacity. The tube full of gas is now slipped over the mouth of a rubber cap, which has been previously filled with the amalgam, see fig. 5 (left side of the wood cut), and sunk in the mercury trough until the liquid is just level with

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the brim. This cap, which is easily made from the "stopper cord," should be capable of holding ten or twenty cubic centimeters of the amalgam, and should tightly clasp the tube. Moreover for this purpose the solid amalgam, above described, should be reduced with mercury to the consistency of a thin paste. The amalgam is now to be shaken up in the tube for several minutes until the decomposition is complete, and then the mouth of the tube may be opened under mercury. The liquid will rise to supply the place of the chlorine which has been absorbed, and on sinking the tube in the mercury trough until the level is the same within as without, it will appear that exactly one-half of the volume has disappeared. As this, however, would require a deep cistern of mercury, and as the interior surface of the tube is left in such a very dirty condition as to obscure the result, we prefer to transfer the tube to a jar of water, which, when the cap is removed, at once displaces the mercury and washes out the interior, without sensibly impairing the accuracy of the experiment.

Water.—The points to be illustrated in the case of water or rather of free steam are all indicated by the equation

$$\boxed{HH} + \boxed{O} = \boxed{H_2O}$$

There is no more striking experiment in this connection than the decomposition of water by sodium, but as made in the usual way the experiment is attended with no little danger. Sodium in certain states explodes violently when brought in contact with water, and after several accidents of this sort we have substituted the solid sodium amalgam above described with the best results. We place an ounce or more of this amalgam in a common gas flask and pour upon it water. The action is very moderate and must be assisted by a gentle heat, but on heating the flask with a gas lamp the gas is evolved rapidly and with great regularity. We collect it over the pneumatic trough and illustrate its properties in the usual way.

We illustrate the fact that water is composed of two volumes of hydrogen to every one of oxygen by the electrolysis of dilute sulphuric acid, using for the purpose the decomposing cell, fig. 1, already described. We collect the gases in two tall bell glasses standing side by side on the shelf of the same pneumatic trough. These bells are of course calibrated and the equal divisions marked by rubber rings. Six cells of Bunsen's battery, medium size, give a rapid evolution of gas.

Lastly we illustrate the fact, that when the elementary gases unite to form aqueous vapor, three volumes are condensed to two, by means of the eudiometer represented in fig. 7. This apparatus is easily made with a common iron casting well known

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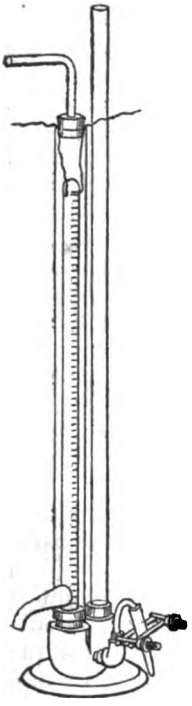
to steam fitters as a "return bend." Any machinist will easily adapt this casting to the required use by attaching to it, as shown in the figure, a circular iron plate to serve as a stand, by also screwing on to one side an ordinary "elbow joint," and at the same time by carefully rimming out the three apertures so as to present smooth surfaces for the adhesion of the rubber stoppers. Into one of the openings of the "return bend" we fasten with a perforated rubber stopper, a common straight *eudiometer tube*, such for example as is ordinarily used in Bunsen's method of gas analysis, while into the second opening we fasten in a similar way an *open* glass tube. In the opening of the elbow joint we secure with a perforated rubber stopper as before, that convenient substitute for a stop cock so well known to chemists as a nipper tap. Last of all we obtain from the glass house a tubulated tube like that shown in fig. 8, of such size that it will cover the eudiometer tube and fit the upper end of the same rubber stopper by which the last is secured in its place. The upper end of this *outer tube* is also closed with a perforated stopper, as shown in the figure, and fine platinum wires, connecting with the wires of the eudiometer, pass between the stopper and the glass. The lower end of the outer tube should not fit too tightly around the rubber stopper so that it can easily be removed when not wanted, moreover all the stoppers should be made of such length that while perfectly tight, they can easily be removed for cleaning the tubes.* These rubber joints, if well made, give great flexibility to the apparatus and enable it to withstand quite rough usage.

7.



8.

The eudiometer being thus mounted, mercury is first poured into the open limb, which is then closed with a rubber stopper and the mercury transferred by inclining the apparatus to the closed limb, this process being repeated until the eudiometer

* It is also best to place around the upper end of the eudiometer tube a rubber ring, quite narrow, but sufficiently thick to fill the annular space when the outer tube is in its place, and also perforated with a number of small holes, so that the steam or vapor, employed in the experiments, may pass freely. This ring confines the eudiometer tube and gives greater solidity to the apparatus.

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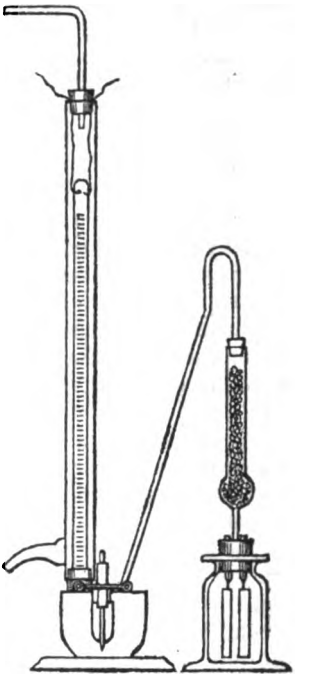
tube is full. The excess of mercury is now drawn out of the open tube by the tap and this tube having been removed the instrument is left as represented in fig. 9. The eudiometer is now ready for receiving the mixed gases, which are passed up into it from a simple decomposing cell, as shown in the figure, the excess of mercury overflowing into any convenient vessel. The *open tube* is now replaced and the outer tube secured in position. It is next necessary to raise the temperature of the eudiometer tube to a point considerably above the boiling point of water and maintain it at this temperature during the rest of the experiment. This is most conveniently done by passing through the *outer tube* the vapor of amylic alcohol (fousel oil,) which may be generated in a flask placed at one side and connected by a glass tube with the upper end of the apparatus. The tubulature at the lower end of the tube should at the same time be dipped into the mouth of a glass bottle into which the alcohol may flow as fast as the vapor is condensed, and since the latent heat of this vapor is very small, this simple method of condensation will be found amply sufficient.

9.



As soon as the temperature of the eudiometer tube is constant, which can easily be told, because the mercury column will then remain at a constant height, mercury must be poured into the open tube or withdrawn from it by the nipper tap until the level is the same in both limbs of the apparatus. It remains now only to note the volume of the confined gas and to explode it by passing an electric spark through the platinum wire already noticed, first, however, tightly closing the end of the open tube with its rubber stopper. When the stopper is removed and the mercury columns again brought to the same level it will be found that the volume of the confined gas has been reduced one-third. The result, however, is always a little too small, because aqueous vapor, even at the boiling point of amylic alcohol, 132° C., does not exactly obey Mariotte's law, and is somewhat more condensed than the *mixed gases* by the atmospheric pressure. It would be better to employ the vapor of a liquid having a still

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higher boiling point, but the results with amylic alcohol are sufficiently accurate for a lecture experiment.*

Ammonia.—The points to be illustrated in the case of ammonia are indicated by the equation $\boxed{H\ H\ H} + \boxed{N} = \boxed{H_3\ N}$.

We demonstrate the composition of ammonia by the old methods which are familiar to every teacher, synthetically by passing a mixture of nitric oxyd and hydrogen over heated platinum sponge as in the beautiful experiment of the late Dr. Hare, and analytically by decomposing aqua ammonia either by electrolysis or by means of chlorine. For the electrolysis of ammonia the decomposing cell fig. 1 may be used, filling it with the strongest aqua ammonia and adding a not too small amount of sulphate ammonia in order to increase the conducting power of the liquid. The reaction is less simple than in the electrolysis either of water or of hydrochloric acid, but as the final results the gasses are evolved, very nearly at least, in atomic proportions, three volumes of hydrogen to one of nitrogen. They can be collected separately in graduated bells as in the electrolysis of water. In decomposing ammonia by chlorine we use with very satisfactory results the apparatus shown in fig. 6 and already described. For this use however a tube should be selected so thin that water may be boiled in it without risk of breaking the glass. The tube having been filled by displacement with pure and dry chlorine gas, we press down the lower end into very weak aqua ammonia (eight measures of water to one of the concentrated solution,) until the liquid flowing in through the overflow tube rises to the height of the first rubber ring. We now quickly close the delivery tube with its rubber cap and allow the absorption to continue until the tube is about half full of the ammonia water when we also close the overflow tube and shake up the liquid in the large tube until all cloudiness has disappeared from the interior. The decomposition is now complete but a considerable amount of the liberated nitrogen still remains dissolved in the liquid. To expel this we heat the tube carefully over a gas lamp until the liquid within begins to boil. On now transferring the apparatus to the pneumatic trough and opening the overflow tube under water it will be found, when the tube cools, that just one-third of the original volume is left and it can easily be shown that the residual gas

* Indeed we can obtain with free steam a result, which is sufficiently near the theory for all purposes of illustration, only it is then important that both the mixed gases and the resulting vapor should be measured under a pressure considerably less than that of the atmosphere. For this purpose a long eudiometer tube should be used and before each measurement the level of the mercury should be adjusted so that it shall stand in the open tube from 10 to 15 inches lower than in the eudiometer. Of course the difference of level must be the same at both measurements.

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is nitrogen. Hence, it follows, since chlorine always combines with its own volume of hydrogen, that ammonia contains only one volume of nitrogen to every three volumes of hydrogen, the point to be proved. To complete this series of illustrations it only remains to show that in ammonia gas the four volumes are condensed to two. For this purpose some dry ammonia gas is passed up into the eudiometer tube as in fig. 9. The side tube is then replaced as in fig. 7, the mercury level adjusted and the position marked with a rubber ring. A stream of electric sparks from a Rühmkorff coil is now passed through the gas, so arranging the connections that the sparks may traverse the whole length of the gas column, and the amount of gas should be small enough to render this possible. The decomposition proceeds somewhat slowly, but after sufficient time on readjusting the level it will be found that the volume of the gas has doubled. Besides the experiments described above, there are many others, to which these same forms of apparatus are applicable; but these will suggest themselves to every teacher and it is not therefore necessary to enter into further details.

Eudiometer.—The eudiometer described above, although originally contrived for the lecture table has proved to be of still greater value in the laboratory, in all processes of gas analysis for which such an instrument is required. It is not only very cheap, simple, and easily repaired, but also equally as accurate as the the most complicated apparatus. It can be used in a room of the most variable temperature; for by passing a current of water, or of steam, as the case may require, through the outer tube the temperature of the eudiometer tube may be easily maintained absolutely constant. The various gases are passed in as shown in fig. 9 and through the same opening the reagents used in the processes of analysis are readily introduced. By replacing the open tube as in fig. 7, and bringing the two mercury columns to the same level, the residual volumes may always be read off under the atmospheric pressure and at a constant temperature, indicated by a thermometer placed in the annular space between the tubes. Or on the other hand by varying the height of the mercury column in the outer tube we may reduce the gas to the same volume and measure the difference of tension according to the method of Regnault. This form of eudiometer is especially adapted for the admirable methods of gas analysis devised by Bunsen. The absorbent balls used by him are most readily introduced when the apparatus is arranged as shown in fig. 9 and the volume of aqueous vapor formed after combustion may easily be measured by replacing the current of cold water through the *outer tube* by a current of free steam. In this case it will be best to measure the gas under as great a difference of pressure as possible, in order to ensure that all the

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water is vaporized and also in order to avoid the somewhat uncertain correction arising from the difference of temperature of the two limbs of the apparatus. This correction, which in most cases is insignificant, becomes important when steam is used, and it is then best to measure directly the difference of level between the mercury in the open mouth of the iron cistern, fig. 9, and that in the tube. This we do by the millimeter divisions on the eudiometer tube with the aid of a very simple contrivance. A split ring of blackened sheet brass, carrying a bent steel wire, is slipped down over the outer tube until the end of the wire just touches the surface of the mercury. The vertical height of this simple measure being known we have only to add to it the height of the mercury column above the upper edge of the ring in order to know the exact difference of level. Of course care must be taken when the measurement is made that the mercury column is vertical, but it is unnecessary to dwell on such obvious precautions, which are essentially the same with this apparatus as those so fully detailed by Bunsen in his work on "Gasometry." It is obvious moreover that the number of these corrections is considerably diminished in using this apparatus as compared with the ordinary mercury pneumatic trough, and besides the convenience and comfort of working in a warm room, it has the additional recomendation that it requires a very small amount of mercury.

The above apparatus as represented in fig. 9 may also be used with great advantage in Gay Lussac's process of determining the density of vapors. The method of using it is obvious to any one who is familiar with the process. After a weighed amount of the liquid under examination enclosed in a thin glass bulb has been passed up into the eudiometer tube it is readily converted into vapor by passing steam or the vapor of some liquid of a still higher boiling point* through the outer tube. All the measurements required in the determination are now easily made. The temperature is measured by a thermometer placed in the annular space between the two tubes and the difference of level of the mercury in the two limbs of the instrument may be most accurately determined by means of a cathetometer aided by the simple contrivance just described.

* Hydrocarbons of high but still constant boiling points, obtained by the methods of Mr. C. M. Warren, might be used with proper precautions in such determinations.

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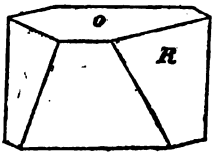
ART. XIX.—*Crystallographic Examination of some American Chlorites;* by JOSIAH P. COOKE, Jr.

THROUGH the kindness of my friend Prof. Brush of New Haven, I have had the opportunity of examining some unique specimens of the Chlorites from the well known locality at Texas, Lancaster county, Pennsylvania. My observations confirm in almost every particular, those previously made by M. Des Cloizeaux and published in his admirable Manuel de Mineralogie, tome i, pp. 433–451; but the perfection of the crystals at my disposal have enabled me to obtain a greater degree of accuracy in my measurements and also to develop some additional facts, especially by comparing the clinochlore from Texas, Pennsylvania, with that from Chester county in the same state and also with that from Chester in Massachusetts.

1.



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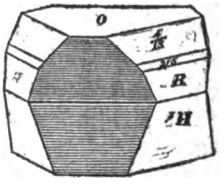

Kämmererite or Violet Chrome Chlorite.—The purest crystals of this beautiful mineral have the form represented in fig. 1. They are generally, however, macled and then appear as in fig. 2. Besides the basal plane O and the planes of fundamental rhombohedron R, these crystals also present the planes of several subordinate rhombohedrons of somewhat variable character, and in addition the basal edges of the rhombohedrons are more or less modified by the planes of hexagonal pyramids, but unfortunately the last are so strongly striated and uneven as to be wholly indeterminable. The violet Kämmererite is frequently mixed with green clinochlore, which gives to the crystals a greenish tinge. On these compound crystals the pyramidal planes are much more dominant than on the crystals of pure Kämmererite, and in this way the crystals of one mineral pass into those of the other, the violet rhombohedrons of Kämmererite merging into the green hexagonal pyramids of clinochlore. We give below in column A, the results of measurements of by far the most perfect crystal of Kämmererite we have examined. The angles italicised are certainly accurate to a minute. In columns B_1 and B_2 we give angles measured on two separate zones of a second crystal and these are important as proving the hexagonal character of the crystal. In column C, we give the fundamental angle measured on still a third crystal. The last two crystals were not so perfect as the first, but still the angles italicised must have been measured accurately within two or three minutes; so that

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the small differences between these values and those in column A are real variations in the angle, such as are quite common in foliated minerals. All the crystals measured were macled as in fig. 2, and we have distinguished the faces of the two members of the macle by the symbol O, R, etc., for the first, and O_1 and R_1 for the second. It is a fact worthy of notice that the faces of the same subordinate rhombohedrons are not necessarily found on both of the twinned crystals, while those of the fundamental rhombohedron are never wanting. On the first crystal we were able to measure every angle of the zone of planes between the opposite basal planes of the macle, and the observations were verified by repeated measurements. It will be noticed that the corresponding angles on the two crystals composing the macle agree absolutely. From these I have calculated the value of the half vertical axis, and from the last I have deduced the values of the angles in the column headed calculated.

$$a = 3{\cdot}4951$$

	Calculated.	Observed.			
		A	B_1	B_2	C
O on R	103° 55′	103° 55′		103° 41′	103° 41′
O on $\frac{4}{13}$R	128° 51′	128° 59′	129° 6′	129° 8′	
O on $\frac{2}{5}$R	121° 47′	121° 54′		122° (nearly)	
$\frac{4}{13}$R on $\frac{2}{5}$R	172° 56′	172° 55′			
$\frac{2}{5}$R on R	162° 8′	161° 59′			
R on R_1	152° 10′	152° 10′			
R_1 on O_1	103° 55′	103° 55′			
O_1 on O_1	180°	180°			
R on R (vertical edge)	65° 36′				

Des Cloizeaux obtained from the same mineral O on R 103° 45′, O on $\frac{2}{5}$R, 122° (about), and from the Pennine of Zermatt for O on R 103° 40′ to 50′.

Optical characters of Kämmererite.—The crystals are *uniaxial*, and the double refraction though *feeble* is distinctly *positive*. The crystals described above as No. 1, showed distinctly the first two rings with the familiar black cross. In white light these rings are alternately blue and pink surrounding a pink-colored center. In homogeneous light the rings formed by the red rays are much narrower than those formed by the blue, indicating the somewhat unusual fact that the crystal exerts the feeblest dispersive power, on the most refracted, in this case the extraordinary, beam. The crystals of Kämmererite are strongly dichroic. By transmitted light in the direction of the optical axis the color is violet; but in all directions at right angles to this, while the color of the ordinary beam is violet, that of the extraordinary is hyacinth-red. Before the blowpipe the mineral gives decided reactions both for chromium and iron.

Pale Green Chlorite.—Accompanying the specimens of Kämmererite I received a single specimen of another variety of Chlo-

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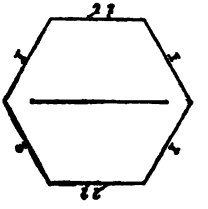
rite having a very pale apple-green color. It came from the same locality, but how closely it is associated with the violet mineral, I have not as yet been able to ascertain. The crystals are six-sided plates with an angle of 120° between the lateral edges, and the edges are beveled by the planes of a very acute hexagonal pyramid. With the exception of the color, and the strong dichroism, which is in a measure the result of the color, the optical qualities are essentially the same as those of Kämmererite. The crystals are uniaxial and they present the same *feeble, positive* double refraction. Moreover the rings formed by red light are narrower than those formed by blue light. Before the blowpipe the mineral gives a decided reaction for iron; but only a very faint reaction if any for chromium, and the difference of color is evidently connected with this difference of composition.

Clinochlore from Texas.—Intimately associated and more or less mixed with Kämmererite are crystals of clinochlore which in their purest condition have a brilliant emerald-green color. These crystals of pure clinochlore are double hexagonal pyramids, but the faces of the pyramids, are so irregular and strongly striated that it is impossible to determine the crystallographic elements of the crystals. The crystals cleave easily parallel to the basal plane and they may thus be readily divided into hexagonal plates with an angle of 120° between the lateral edges. These plates show a strong double refraction and the plane of the optical axes is parallel to the edge of the hexagonal section as shown in fig. 3. The bisectrix of the acute angle between the optical axes is positive, and inclined at a variable angle to the normal of the plane of cleavage. The angle between the optical axes is also exceedingly variable. The following angles were measured on cleavage plates from different crystals. These are not of course the true angles; but the great fluctuations of the value makes any reduction of the observations unimportant.

3.



	Apparent angle between optical axes.	Apparent angle between bisectrix and normal.
No. 1,	84°	15° 30′
No. 2,	79°	
No. 3,	67°	13° 30′

The dispersion of the axes is quite evident, and in every case $\rho > v$. Moreover, the system of rings, when seen by white light, shows a slight but distinct difference of form at the two ends, thus indicating that the general dispersion of the system is longitudinal;* and this characteristic further indicates that the crys-

* The modifications in the biaxial system of rings called by Des Cloizeaux "dispersion inclinée," "dispersion horizontale" and "dispersion croisée ou tournante" we

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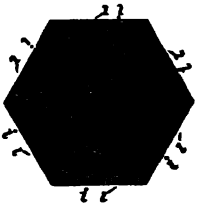
tals belong to the monoclinic system, and that the optical axes are in the plane of symmetry. These crystals of clinochlore also show a marked dichroism. The color by transmitted light in the direction of the optical axis is emerald green but in all directions at right angles to the axis, while the color of the ordinary beam is green, that of the extraordinary is reddish yellow.

The crystals of clinochlore from Texas are almost invariably macled. The ideal macle, if I may use the term, consists of three crystals interpenetrating each other, as is shown in section in fig. 4 where the portions of different crystals are distinguished by the shading, the lines of the shading indicating also the position of the plane of the optical axes. It is seldom the case, however, if ever, that the macles have the regularity, which our figure would indicate, although I have frequently observed on different parts of the same plate three different systems of rings, the planes of whose axes make angles of 60° with each other. In an intermediate position a complex form would be seen resulting from the overlapping and interfering of the three systems. Generally, however, the crystals are united in very unequal proportions, some one or two being present in very great excess and giving rise to corresponding irregularities in the figures seen by polarized light. With many plates the combined figure just spoken of would alone be seen, while with others you would see over most of the plate only one ring system, a single corner perhaps showing evidence of macling. When, as is frequently the case, the crystals of clinochlore enclose those of Kämmererite the result is still more complex. At times the crystal of Kämmererite forms the nucleus of a larger crystal of clinochlore, while in other cases these two heteromorphous minerals seem actually to interpenetrate each other; and in all cases the cleavage planes of the two crystals absolutely coincide. The crystals of clinochlore thus acquire *a violet tinge* and at the same time the angle between the optical axes is diminished. Moreover we have observed on such crystals a character not unlike that first noticed by De Senarmont on certain artificial crystals and to which he referred the variation in the angle of the optical axes of the micas. Thus on moving a plate of violet tinged clinochlore parallel to itself in front of the polarizing microscope I found that the angle between the optical axis varied as I passed from one side of the field to the other. The successive values which

4.



have named in English longitudinal, lateral and circular dispersion. The English terms are not the exact equivalents of the French words, but they express the idea that the effect of light of different colors is, in the first case to move the system of rings longitudinally, in the second case to move it laterally, and in the third case to revolve it through a small angle around the bisectrix.

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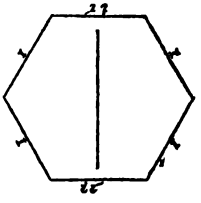
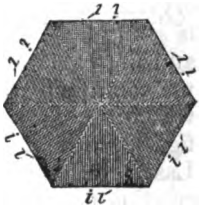
I obtained were 27°, 26°, 19° 30′, 18°, 17°, 16°. On another plate beginning with an angle of 30° I next measured an angle of 18°. Moving the plate still farther, always parallel to itself, the axes closed together and then again opened as I passed on to another portion of the macle. It will be noticed that the largest of these angles is much smaller than those observed on crystals of pure clinochlore, and on placing a plate of pure Kämmererite behind a plate of pure clinochlore I observed not only that the angle between the optical axes was diminished but also that the color of the light transmitted through the two plates was precisely the same as that seen through plates of the compound crystals we have been discussing.

Clinochlore from Chester county, Pennsylvania.—In connection with the clinochlore from the Chrome Iron Mines of Texas, Pa., I have reëxamined that from the serpentine of West Chester in the same state. As is well known these large crystals are so exceedingly irregular that the form cannot be accurately determined. Like other crystals of chlorite, they have an easy micaceous cleavage, and the cleavage section is either hexagonal or triangular, the angle between the adjacent edges of the section measuring 120° or 60° as the case may be. The optical characters are in most respects the same as those of the corresponding mineral from Texas. There is the same strong double refraction and biaxial character, the same inclination of the bisectrix to the plane of cleavage, the same variation in the angle between the optical axes, the same system of macles, the same color and the same dichroism; but still there is one important exception. The line uniting the centers of the biaxial image is not parallel but perpendicular to the edge of the hexagonal section as is shown in fig. 5. This fact first observed by Mr. W. P. Blake I have verified on a number of different plates, and I have not been able to find a single exception to the rule. Moreover, this position of the plane of the optical axes is preserved in the macles. An ideal section of such a macle is represented in fig. 6, where as in fig. 4 the position of the plane of the optical axes on different parts of the plate is indicated by the lines of the shading; and in some plates this ideal arrangement is very nearly preserved, although generally we find the same irregularities already noticed on the macles from Texas. Lastly, the dispersion is not *longitudinal* but *lateral*. This dispersion of the biaxial image is so slight, however, that it might be readily overlooked. It is manifested only by a slight difference in the curvature of the rings and in the

5.



6.



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intensity of their color on the two sides of the image, but then this difference is constant and after examining a large number of plates placed in different positions in the field of the microscope I was left in no doubt as to the fact. It follows then, that while these crystals are monoclinic and the position of the bisectrix is the same as in the crystals from Texas, the plane of the optical axes instead of coinciding with the plane of symmetry is at right angles to this plane.

Clinochlore from Chester, Massachusetts.—Through the kindness of Dr. C. T. Jackson of Boston I have had the opportunity of examining some well-characterized chlorite crystals, which occur at the emery mine of Chester, Mass., in connection with diaspore and its associated minerals. The crystals are double hexagonal pyramids but very rough and irregular. They have a micaceous cleavage yielding an hexagonal section, and the angle between the adjacent edges of the section measured on two different plates exactly 120°. The optical characters are all those of clinochlore; strong double refraction; biaxial image with the bisectrix inclined to the cleavage plane; and moderate dispersion of the axes $\rho > \nu$. Moreover the angle between the optical axes is very variable. I measured on different cleavage plates, all from this one locality, the angles 73° 30′, 71° 30′, 45°, 32°. The line joining the centers of the biaxial image is perpendicular to the edge of the hexagonal section, and the dispersion of the image is lateral as in the crystals from Chester Co., Pa. Indeed these crystals resemble the last in almost every respect except that they are smaller, have a deeper color, and are not so generally macled.

Analogies between the Chlorites and Micas.—Although these two minerals crystallize in very different systems, yet the analogies between their crystalline characters is very remarkable. In crystals of both minerals the section made by the cleavage plane is a regular hexagon; in both, the double refraction is strong and the angle between the optical axes is very variable; in both we can distinguish two optically distinct varieties, in one of which the plane of the optical axes has the position shown in fig. 3, while in the other it has the position shown in fig. 5. Lastly Kämmererite and Pennine stand in somewhat the same relation to the two varieties of clinochlore that Vesuvian Biotite stands to the two corresponding varieties of mica, although it must be remembered, that while the double refraction of the uniaxial chlorite is very feeble that of the uniaxial mica is still quite strong. Mineralogists generally admit with DeSenarmont that the variations in the optical axes of the micas result from the mutual influence of the two optical varieties and the facts of this paper tend to show that the same influence is exerted on the chlorites.

Cambridge, June 29th, 1867.

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ART. XX.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School*, No. 3; by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

§ 1. *On a new general method of volumetric analysis.*

IN a memoir on the quantitative determination of nitric acid, H. Rose* suggested that in particular cases the metal in the nitrate might be precipitated by means of sulphydric acid, and the nitric acid set free determined in the filtrate by volumetric methods. So far as this application of the volumetric analysis is concerned, Rose's method appears not to have been carried out in practice or even supported by actual experiment. It occurred to me that the method might be generalized so as to form the basis of a new application of the processes of acidimetry, and the following analyses will serve to show the degree of accuracy which may be attained. When the salt to be analyzed contains a fixed acid which does not act upon sulphydric acid gas, a weighed portion is to be dissolved in water, the solution brought to a boiling heat and a current of sulphydric acid gas passed through until the metal is completely precipitated. When quantities of about 5 grams are employed the precipitation is usually complete in half an hour. The precipitate may then be allowed to settle and a drop of the supernatant liquid taken out with a glass rod and tested upon a white porcelain plate, with a drop of a saturated solution of sulphydric acid in water, or with any other reagent which may be specially adapted to the metal in the salt examined. The precipitation being complete the liquid is filtered upon a ribbed filter, the filtrate and the washings allowed to flow into a half liter or liter measure, and the washing with hot water continued until a drop of the filtrate no longer exhibits an acid reaction. The liquid is then allowed to cool and the volume made up to exactly a half liter or liter by the addition of water. After thoroughly mixing the contents of the measure, fifty or one hundred cubic centimeters are to be taken out, a few drops of a solution of cochineal or logwood added, and the free acid determined by means of $\frac{1}{10}$ normal ammonia in the usual manner. The first determination is to be used simply as a guide. Two or more successive portions of the acid liquid may then be taken out and determined successively, and the mean of several determinations obtained. With very little practice the results will be found to correspond to $\frac{1}{10}$ c. c. when a burette with Erdmann's swimmer is employed. From the quantity of ammonia required to neutralize the acid, the quantity of acid, and in many cases also of base, in the salt may be readily calculated.

* Pogg. Ann., B. cxvi, p. 125.

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With crystallized sulphate of copper the following results were obtained.

1·8435 gr. sulphate	gave 31·89 p. c. acid	"	"	and 31·70 p. c. base		(Sharples)
3·7183 gr. "	gave 32·14 "	"		and 31·93 "	"	(Sharples)
8·3955 gr. "	gave 32·10 "	"		and 31·89 "	"	(Tower)

The formula $\mathfrak{C}u\mathfrak{S}\Theta_4+5aq$ requires ($\mathfrak{C}u=63·50$).

		I.	II.	III.
$\mathfrak{C}u\Theta$,	31·86	31·70	31·93	31·89
$\mathfrak{S}\Theta_3$,	32·07	31·89	32·14	32·10

The first analysis was made with a commercial sulphate, the other, with a pure salt prepared from electrotype copper. In crystallized sulphate of copper and potassium, ($\mathfrak{C}u\mathfrak{S}\Theta_4+K_2\mathfrak{S}\Theta_4+6aq.$) 2·6601 gr. gave 18·23 per cent acid and 18·11 per cent oxyd of copper. The formula requires

		Found.
$\mathfrak{C}u\Theta$,	18·00	18.11
$\mathfrak{S}\Theta_3$,	18·12	18·23

In the memoir already referred to Rose points out the necessity of diluting the solutions of metallic nitrates to such a degree that the nitric acid set free shall not act sensibly upon the sulphydric acid.

In the experiments made in my laboratory to test the method this precaution was not found to be sufficient. Thus with crystallized nitrate of lead, Mr. Sharples obtained the following results.

I. 2·147 grams of salt were dissolved in 200 c. c. water and the lead precipitated from the boiling solution by sulphydric acid gas. The filtrate was made up to 500 c. c. of which three portions containing each 75 c. c. were taken for titrition and each required 18·2 c. c. of ammonia. This gives 30·51 per cent of nitric acid, while the formula $\mathfrak{P}b(N\Theta_3)_2$ requires 32·61 per cent.

II. 2·4992 of the nitrate were dissolved in 500 c. c. of water and treated as above, only the lead was thrown down in the cold by sulphydric acid, and the excess of the latter expelled from the filtrate by boiling. The acid found corresponded to 32·12 per cent in place of 32·61. From this it is clear that even dilute nitric acid acts too powerfully upon sulphydric acid to permit a very accurate determination of the former under the circumstances of the experiment. Precipitation from a boiling solution is necessary because the filtrate is then at once free from sulphydric acid.

To obviate the difficulty arising in the case of nitric acid it occurred to me to add to the solution of the nitrate a portion of a neutral salt containing a fixed organic acid, an equivalent quantity of which would be set free by the combination of the free nitric acid with the base contained in the salt. This method

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was found to give perfectly satisfactory results, as the following analyses by Mr. S. P. Sharples will show.

4·409 grams of nitrate of lead were dissolved in 200 c. c. of water, five or six grams of pure Rochelle salt added and the lead precipitated as above. The quantity of acid found corresponded to 32·58 per cent. The formula $Pb(N\Theta_3)_2$ requires

		Found.
$N_2\Theta_5$,	32·63	32·58
$Pb\Theta$,	67·37	67·27

0·9380 gram of nitrate of bismuth were treated as above, Rochelle salt being added. The nitric acid found, corresponded to 33·40 per cent and the equivalent quantity of oxyd of bismuth to 47·82 per cent. The formula $Bi(N\Theta_3)_3+10aq$ requires

		Found.
$N_2\Theta_5$,	33·47	33·40
$Bi_2\Theta_3$,	47·94	47·82

5·6553 gr. of chlorid of mercury were treated as above, six or eight grams of Rochelle salt being added to the solution. The free acid corresponded to

	Calc.	Found.
Cl_2,	26·20	26·10
Hg,	73·80	73·90

When chlorine is separated in the form of chlorhydric acid the volatilization of the acid in the process of boiling is completely avoided by the addition of the organic salt. The same remark applies to nitric acid, though it is probable that the principal cause of loss in this case is the action of the acid at a boiling heat upon the gas passed through the liquid. The precipitation of a metal by sulphydric acid is usually much slower when boiling solutions are employed.

The analyses given above show that, under favorable circumstances, the method employed is capable of giving satisfactory results. It is easy to see that it applies in the case of soluble definite compounds of all those metals which are easily and completely precipitated from boiling solutions by means of sulphydric acid gas. When the compound to be analyzed contains an excess of free acid not combined with the oxyd of the metal to be determined, this must be first separated by evaporation to dryness in the usual manner. The presence of alkalies and alkaline earths is of course without influence on the result, but on the other hand even very small quantities of iron, alumina and various other bases make it almost impossible to determine the point of saturation with precision, these oxyds in solution giving with cochineal and logwood specific reactions not easily distinguished from those produced by the alkalies in excess. For this reason the method does not apply when oxyds of this class are present, and this case is precisely that which

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most frequently occurs in practice. The method will be applicable to all these cases if hereafter a coloring matter should be discovered sensitive only to acids or bases in excess, but not producing specific coloration with salts which are neutral in constitution. It is possible that cyanin, the remarkable properties of which have been described by Schönbein, or the rosocyanin of Schlumberger,* may fulfil the condition indicated, but I have had no opportunity of experimenting with either.

The method of precipitation above described may be used with advantage in preparing a pure normal acid for titrition. Pure crystallized sulphate of copper is to be powdered and heated in a porcelain crucible placed within a Hessian crucible for about an hour, the temperature being gradually raised and not allowed to exceed a low red heat. The anhydrous sulphate is then while still hot to be transferred to a perfectly dry glass tube which can be closed with a good cork covered with tin foil. After cooling, the tube is weighed, the contents poured into a flask, the salt dissolved in water and the copper precipitated at a boiling heat as above. The filtrate and washings are then to be made up to a known volume. From the weight of the anhydrous sulphate employed the quantity of sulphuric acid present in the solution is known. In experiments made in this laboratory by Mr. R. Chauvenet this method has been found very accurate and expeditious.

§ 2. *On the precipitation of copper by hypophosphorous acid.*

In a memoir on the hypophosphites, A. Würtz† has shown that when solutions of copper are heated to 70° C. with hypophosphorous acid a hydruret of copper is precipitated, which on boiling is reduced to metallic copper with evolution of hydrogen. On repeating this experiment I found that the precipitation of copper is complete, and as the alkaline hypophosphites are now to be had in commerce, it appeared probable that the process might be applied to quantitative estimation. Experiments to determine this point have been made by Mr. R. Chauvenet with the following results:

The copper should be in solution as sulphate, the liquid containing a little free acid. The precipitation from the nitrate is always incomplete. When chlorhydric acid or chlorids are present the method fails entirely, the copper being reduced to subchlorid and remaining in solution. The solution must not be too dilute; the precipitation is complete if the saturated solution of sulphate be diluted with not more than ten times its bulk of water, before the addition of the hypophosphites. In order to avoid the sudden evolution of hydrogen gas, and also to ob-

* Bull. de la Société Chimique, Mars, 1866, p. 194.

† Ann. de Chimie et de Physique, 3d series, vol. vi, p. 199.

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tain the precipitate in a spongy coherent form, it is best not to allow the liquid to boil. The solution of hypophosphite having been added in the cold and in excess, the temperature is to be gradually raised until, after standing for some minutes between 80° C. and 90° C., the hydruret of copper has entirely separated in coherent masses. It is easy to determine when the precipitation is complete by taking out a drop of the clear liquid with a rod and testing upon a porcelain plate with a drop of sulphydric acid solution. No filter need be used if the precipitation be effected in an assay flask; the copper is easily washed by decantation, and may then be transferred to a porcelain crucible by the well-known method of inversion, dried and gently ignited in a current of hydrogen. The following analyses will serve to illustrate the accuracy of this method. In all of them hypophosphite of magnesium was employed as the precipitant.

1.	1·1650 gr.	pure sulphate of copper	gave	0·2965 gr.	copper	=25·45	p. c.	(Chauvenet.)
2.	1.5590 gr.	"	"	" 0·3970 gr.	"	=25·45	"	"
3.	1·4255 gr.	"	"	" 0·3625 gr.	"	=25·43	"	"
4.	1·3050 gr.	"	"	" 0·3327 gr.	"	=25·42	"	(R.B.Carman)
5.	0·8208 gr.	"	"	" 0·2087 gr.	"	=25·42	"	(E. F. Gale.)

In (4) and (5) a large excess of sulphate of nickel was present.

The formula $CuSO_4+5aq$ gives 25·42 per cent of copper. In the third analysis sulphates of iron, manganese, nickel and zinc in very large excess were added to the solution of copper.

I. In a very pure subsulphid of copper from Arizona, Mr. Chauvenet found in four analyses 74·24, 74·37, 74·36 and 74·41 per cent copper.

II. In an alloy of copper and nickel

6.	0·4245 gr.	gave	0·3605 gr.	of copper	=84·92	per cent.	(Chauvenet.)
7.	0·3615 gr.	"	0·3070 gr.	"	=84·92	"	"
8.	0·1380 gr.	"	0·1170 gr.	"	=84·85	"	"
9.	0·1980 gr.	"	0·1680 gr.	"	=84·84	"	"

III. In brass wire

10.	1·6300 gr.	gave	1.0705 gr.	of copper	=65·67	per cent.	(Chauvenet.)
11.	1.8655 gr.	"	1·2240 gr.	"	=65·61	"	"
12.	1·6770 gr.	"	1·1010 gr.	"	=65·65	"	"

In the last seven analyses the alloy was dissolved in sulphuric acid, nitric acid being added from time to time to assist in solution. The solution was then evaporated until the last traces of nitric acid were expelled. The presence of iron in the form of sulphate does not in any way interfere with the complete precipitation of copper by hypophosphite of magnesium. When sesquichlorid of iron is present, however, the copper is always reduced to subchlorid and is not precipitated as metal or hydruret. A solution of a hypophosphite reduces sesquichlorid of iron to protochlorid: the reduction is particularly rapid and com-

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plete when a salt of copper is also present and the liquid contains free chlorhydric acid. I have endeavored to base upon this reduction a method for determining iron volumetrically, but all the experiments failed in consequence of the difficulty of determining the exact point at which the reduction of the iron is complete. Sulphocyanid of potassium, proposed for this purpose by Winkler* in his process with subchlorid of copper as a reducing agent, was not found to give sharp indications. When copper and iron are present together as chlorids, the addition of hypophosphite of magnesium simply reduces the copper to subchlorid as above stated. If in this case we add an alkaline chlorid to keep the subchlorid of copper dissolved, the copper may be easily precipitated as subsulphid by sulphydric acid gas. When arsenic or antimony are present with copper these must first be separated before precipitating the copper as hydruret, as careful experiments by Mr. C. Lilly have shown that both arsenic and antimony are precipitated with the copper. Mr. Lilly obtained the following analytical results when arsenous acid was present.

1·2690 gr.	sulphate of copper gave	0·3279 gr.	metallic copper	=25·83	pr. ct. copper.
1·5127 gr.	" "	0·3905 gr.	"	=25·77	" "
0·9638 gr.	" "	0·2509 gr.	"	=26·03	" "

The formula gives 25·42 of metallic copper. In presence of antimonious acid—

0·7100 gr. sulphate of copper gave 0·2454 gr. copper = 34·56 per cent.

After addition of $Sb_2\Theta_3$ and Rochelle salt.

0·9875 gr. sulphate of copper gave 0·2426 gr. copper = 24·56 per cent.

Repeated analyses by Mr. Lilly also showed that copper could not be determined accurately in Schweinfurt green by hypophosphite of magnesium, and that the presence of Rochelle salt did not completely prevent the precipitation of arsenic with the copper when arsenous or arsenic acid were mixed with sulphate of copper.

In assaying copper ores it is usually desirable to bring the metal at once into the form of sulphate. Numerous experiments made in this laboratory fully justify me in recommending the following method. The finely pulverized ore (sulphids of copper and iron) is to be mixed in a porcelain crucible with three or four times its weight of a mixture of one molecule of bisulphate and one of nitrate of potassium. The mixture is then to be slowly heated to low redness, which is best accomplished in a muffle. The metallic sulphids are completely oxydized without the least frothing of the heated mixture. Enough strong sulphuric acid to convert all the sulphate of potassium into bisul-

* Zeitschrift für Analytische Chemie, Bd. iv, p. 423.

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phate is then added, and the crucible is to be again carefully heated until the contents run to a clear fused mass. On cooling the mass usually separates readily from the crucible which is not attacked, and on solution the iron and copper are found completely converted into sulphates. This process has been tried successfully with a great variety of ores. The whole operation requires about an hour. In the case of ores containing much bisulphid of iron it is best to heat the powdered ore first as long as sulphur is given off, and afterward to add the oxydizing mixture and heat as above. The sulphids of lead, zinc and antimony are completely oxydized by the same process.

§ 3. *On the precipitation of copper and nickel by alkaline carbonates.*

The precipitation of copper by zinc or by the electrolytic method requires that the metal should be present in the form of sulphate or chlorid and does not succeed with the nitrate. As stated above the employment of the hypophosphites is limited to the case in which the metal exists as sulphate. The old mode of precipitating copper as oxyd by caustic potash has disadvantages which are familiar to all chemists, but on the other hand is independent of the nature of the solution of copper employed so long at least as no organic matter is present. According to Rose* the alkaline carbonates precipitate copper less completely than caustic alkalies. This statement, however, is not accurate for *all* the conditions under which the experiment may be performed; and I have found that copper may be completely precipitated from the sulphate, nitrate or chlorid when the solutions are boiled together for a sufficient time and are sufficiently dilute. Mr. E. R. Taylor, who has made a careful study of this method of determining copper, has arrived at the following as the best method of conducting the process. The solution of copper is to be diluted with water until the liquid contains not more than about one gram of the metal in one litre. A solution of carbonate of potash or soda is then to be added in small excess, and the whole boiled for about half an hour. The boiling proceeds quietly and without succussions; the blue green carbonate soon becomes dark brown, and has a fine granular character which renders it extremely easy to wash. After washing it is to be ignited in an atmosphere of hydrogen, and the copper weighed as metal; it will be found to be free from alkali. In this manner Mr. Taylor obtained in five analyses the following results:

1·8384 gr.	pure	sulphate	of	copper	gave	0·4688 gr.	metallic	copper	=	25·44 pr. ct.
1·7144 gr.	"	metallic	cop.	dissolved	in aqua regia	gave	1·7161 gr.	cop.	=	100·09 p. c.
1·3860 gr.	"	"	"	"	"	"	1·3853 gr.	"	=	99·93 "
1·4657 gr.	"	"	"	"	nitric acid	"	1·4670 gr.	"	=	100·09 "
1·4685 gr.	"	"	"	"	"	"	1·4634 gr.	"	=	99·65 "

* Handbuch der Analytischen Chemie, ii, 175. Sechste Auflage.

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The filtrate is perfectly free from copper if the process has been well conducted.

The ignited oxyd is in a state of great subdivision, and the ignition must therefore be conducted with much care to avoid loss. A small portion of the oxyd or basic carbonate usually adheres to the sides of the vessel in which the boiling takes place. This is to be re-dissolved, and again precipitated, but great care must be taken not to add a large excess of the alkaline carbonate, which gives a solution from which the copper is not precipitated by boiling.

Nickel may be completely precipitated from its solutions by precisely the same process. The green basic carbonate may be washed much more readily than the oxyd precipitated by caustic alkali; it is to be ignited and weighed as oxyd. In two analyses Mr. Taylor obtained the following results.

1·9808 gr. anhydrous sulphate of nickel gave 0·9551 gr. $Ni\Theta$=37·79 p.c.
1·4601 gr. " " " " 0·7008 gr. $Ni\Theta$=37·64 "

The formula $NiS\Theta_4$ requires 37·69 (Ni=58). Dr. F. A. Genth informs me that he has also used the alkaline carbonates in precipitating nickel, and with most satisfactory results.

The precipitation of cobalt by an alkaline carbonate can only with much difficulty and by long boiling be made complete. As a means of determining cobalt it is not to be recommended. On the other hand Mr. F. W. Clarke has found that cobalt is completely and easily precipitated by the process of oxydation first given by Popp,* which consists in neutralizing the solution with carbonate of sodium, adding acetate of sodium and then boiling with an excess of an alkaline hypochlorite, taking care to keep the solution alkaline. The hydrated sesquioxyd (?) of cobalt thrown down may be readily washed. After reduction in hydrogen the metal is found to be free from alkali. Nickel may, as Popp has also shown, be precipitated in the same manner, but the process given above seems to me preferable.

In this connection I may be permitted to state that the method of separating cobalt from nickel by means of peroxyd of lead attributed to myself in the new edition of Rose's† Handbuch der Analytischen Chemie and also ascribed to me by Gauhe‡ was never even proposed by me.

Cobalt and nickel may be precipitated from neutral solutions of their sulphates, nitrates and chlorids by adding first an excess of oxalic acid to the concentrated solution and then a large excess of strong alcohol. After standing a few hours the filtrate is perfectly free from metal. The oxalates are very easily washed. This method is, however, rarely available for analyt-

* Zeitschrift für Analytische Chemie.
† Sechste Auflage, Bd. ii, p. 143.
‡ Zeitschrift für Analytische Chemie.

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ical purposes, since it fails entirely when salts of ammonium or of the alkaline metals are present. The oxalates are also in such a state of subdivision that it is almost impossible to ignite them without loss. The oxyds of copper, cadmium, zinc, manganese and magnesium, are also completely precipitated from their sulphates by oxalic acid and alcohol, but not in presence of alkaline salts. The same is true of both mercurous and mercuric nitrates. In the few cases in which this mode of precipitation will find application in practice it will probably be best to determine the oxalic acid in the oxalate by hypermanganate of potash.

In a former paper I have stated that the sulphids of cobalt and nickel thrown down from boiling solutions by a boiling solution of sulphid of sodium may be washed without oxydation upon the filter. The difficulty of preparing pure sulphid of sodium has, however, been an objection to this method.* This difficulty may easily be removed by dissolving the crystallized tetrahedral sulphid, Na_2S+9aq, in alcohol of 90 per cent, filtering and allowing the solution to crystallize. After two or three crystallizations the pure sulphid may be dried over sulphuric acid in vacuo and the white effloresced mass preserved in a well stoppered bottle. The sulphid is chemically pure.

§ 4. *On the employment of sand and glass filters in quantitative analysis.*

Sufficient attention has not been paid to the advantages of filters of sand and glass over those of paper, when precipitates are to be dried upon the filter at a definite temperature. By choking the throat of a funnel with coarse fragments of glass and then placing upon these successive layers of powdered glass or sand, the upper layer being of the finest powder, it is easy to make a filter upon which almost any precipitate may be filtered off and washed out completely without the slightest loss. The funnel with its contents may then be dried at any temperature below that at which the glass softens or at which the precipitate undergoes chemical or physical change. Mr. E. R. Taylor, who has carried out this suggestion with the greatest care and thoroughness, obtained the following results in three analyses of tartar-emetic.

I.	0·0917 gr.	tartar-emetic	gave	0·0463 gr.	Sb_2S_3	= 36·09	per cent	Sb.
II.	0·6236 gr.	"	"	0·3149 gr.	"	= 36·08	"	"
III.	0·1766 gr.	"	"	0·0891 gr.	"	= 36·07	"	"

The formula requires 35·92 per cent (Sb=120).

In the first and second analyses the precipitated sulphid was dried at 375° C. In the third the funnel had the shape of a tube

* This Journal, vol. xxxvii, p. 350, also Zeitschrift für Analytische Chemie, Bd. iii, p. 392.

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tapering at one end and dilated in the middle to a sort of bulb, and the precipitated sulphid of antimony after drying was ignited in the filter tube itself in a current of carbonic acid gas. This form of funnel, which is due to Mr. Taylor, will be found very advantageous. A small common funnel may be inserted into the top, and after drying, the tube funnel closed with a cork in weighing.

§ 5. *On the estimation of manganese as pyrophosphate.*

The existence of an ortho-phosphate of manganese and ammonium corresponding to the well known salt of magnesium, was long since ascertained by Otto.* The subject has more recently been studied by Debray† who has described a series of analogous phosphates, all of which are remarkable for their insolubility. Otto's salt, $P_2O_8Mn_2(NH_4)_2+2H_2O$, from its highly crystalline structure, the facility with which it is formed, and its insolubility, appeared well adapted to the quantitative estimation of manganese, and the following analyses show that this metal like magnesium may be advantageously precipitated as ammonia-phosphate and weighed as pyrophosphate.

To the solution of manganese, which may contain salts of ammonium or of the alkaline metals, disodic orthophosphate is to be added in large excess above the quantity required to precipitate the manganese as orthophosphate. The white precipitate is then to be redissolved in excess of sulphuric or chlorhydric acid, heated to the boiling point and ammonia added in excess. A white or semi-gelatinous precipitate is produced which, on boiling or standing for some time even in the cold, gradually becomes crystalline and finally is completely converted into beautiful talcose scales which have a pearly luster and a pale rose color. It is best to precipitate each time in a platinum vessel in which the ammonia-phosphate may be boiled for ten or fifteen minutes, and to allow the salt to remain at a temperature near the boiling point of the liquid for an hour after it has become crystalline. The ammonia-phosphate may then be filtered off and washed with hot water. The washing takes place with extraordinary facility on account of the crystalline character of the salt. The orthophosphate after drying and ignition yields pyrophosphate of manganese as a nearly white powder. In this manner

1. 0·9555 gr.	$MnSO_4$	gave	0·8985 gr.	$P_2O_7Mn_2$	= 46·68	p.c.	MnO
2. 1·1400 gr.	"	"	1·0717 gr.	"	= 46·67	"	"
3. 0·8145 gr.	"	"	0·7646 gr.	"	= 46·63	"	"

(Chauvenet.)

* Bull. de la Société Chimique. Nouvelle Série ii, p. 11.
† Ann. der Chemie und Pharmacie, viii, 173.

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4.	0·9464 gr.	$MnSO_4$	gave	0·8886 gr.	$P_2O_7Mn_2$	= 46·66	p. c.	MnO
5.	1·3181 gr.	"	"	1·2390 gr.	"	= 46·68	"	"
6.	1·0565 gr.	"	"	0·9950 gr.	"	= 46·76	"	"

(Gordon.)

The formula requires 46·67 per cent ($Mn = 54$). The sulphate employed was pure and perfectly anhydrous. In two analyses of crystallized chlorid of manganese not quite free from mechanically mixed water, Mr. F. W. Clarke obtained 27·08 and 27·07 per cent of manganese. In the same salt the percentage of chlorine was found to be 35·68 which corresponds to 27·14 per cent of manganese.

The advantage of this method over that commonly employed for the estimation of manganese, is that the process permits us to weigh the metal in the form of a perfectly definite compound and not as an oxyd which cannot be safely assumed to consist wholly of Mn_3O_4. When manganese is associated with the alkaline earths it is of course first to be separated as sulphid, or by Schiel's method as a hydrate of the sesquioxyd. The ammonia-phosphate is almost absolutely insoluble in boiling water, in ammonia and in solutions of salts of ammonium. The salt is nearly white but sometimes becomes a little more red upon the filter. If it assumes a rather deep dull red color the whole of the phosphate of manganese has not been converted into ammonia-phosphate. The precipitate is then to be redissolved in dilute chlorhydric acid, more phosphate of sodium added and then ammonia in excess, after which the boiling is to be repeated. This repetition is very rarely necessary, a little practice enabling the analyst to judge when the conversion from the flocky-gelatinous to the crystalline condition is complete. The filtrate from the crystalline salt is perfectly free from manganese. Phosphoric acid cannot be determined by precipitation as ammonia-phosphate of manganese, because the crystalline character of the salt upon which the success of the process depends is only produced by digestion with an excess of phosphate. Bette* has described an ammonia-phosphate of zinc which, like the corresponding manganese salt, is almost absolutely insoluble in water. Debray† has analyzed similar salts of nickel and cobalt, and Otto‡ has also described the analogous ammonia-phosphate of iron. I have myself prepared an ammonia-phosphate of cadmium which, like the other salts of this group, is extremely insoluble in water. All of these salts however, are more or less readily soluble in ammonia and in salts of ammonium, and after repeated trials I have not succeeded in rendering any of them available for analytical purposes.

Cambridge, June 20th, 1867.

* Ann. der Chemie und Pharmacie, xv, 129. † Loc. cit.

‡ Ann. der Chemie und Pharm. xvi, 199.

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Art. XXI.—*Note on the action of peroxyd of manganese upon uric acid;* by C. Gilbert Wheeler.

The oxydizing action of the peroxyds upon organic substances varying to some extent according to the peroxyd employed, I have investigated the action of peroxyd of manganese upon uric acid.

If uric acid and peroxyd of manganese are heated together with a like quantity of water and sulphuric acid is added in small portions at a time until no further action is to be observed, the black pasty mass then filtered, and the filtrate evaporated to about one-fourth of its original volume, there is obtained after considerable time, a quantity of large hexagonal crystals, which by analysis and characteristic reactions was found to be parabanic acid.

If uric acid is heated with a large quantity of water only, until the latter is brought to the boiling point and then peroxyd of manganese added as long as evolution of carbonic acid occurs and the mass filtered, there remains on the filter peroxyd of manganese and oxalate of manganese, while the filtrate on being somewhat concentrated yields crystals, which if again dissolved and treated with animal charcoal may be obtained colorless and quite pure. They were tasteless, rather difficultly soluble in cold but readily soluble in warm water; the solution gave with chlorid of mercury no precipitate, while a very voluminous one was obtained on adding the nitrate of the same base; nitrate of silver and ammonia gave a white glistening precipitate; on heating, cyanid of ammonium was evolved.

0·3595 grams yielded on combustion 0·133 water and 0·398 carbonic acid; which relation indicated the substance to be *allantoin.*

	Found.	Theory.
C	30·13	30·4
K	4·09	3·8

The mother-liquor contained much urea, also an amorphous substance; the quantity of which was too trifling to admit of an analysis. The action of the peroxyd of manganese may be explained by the following exquation.

$$3(C_{10}H_4N_4O_6)+6MnO_2+8HO=2(C_8H_6N_4O_6)+2(C_2O_2H_4N_2)+4(MnO, C_2O_3)+2(MnO, CO_2).$$

If uric acid is heated with peroxyd of manganese in the presence of but a small quantity of water there is formed urea, oxalic and carbonic acid, and but a very small quantity of allantoin; the action of peroxyd of manganese upon uric acid resembles therefore very closely that of peroxyd of lead.

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ART. XXII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XV.—*Observations on the native hydrates of Iron;* by GEORGE J. BRUSH, *with analyses of Turgite by* CHARLES S. RODMAN.

THE well known iron mines of Salisbury, Conn., have long enjoyed a reputation among mineralogists as furnishing superior specimens of *limonite*, and hitherto this has been thought to be the only ferric hydrate occurring in quantity at this locality. Minute crystals of supposed Göthite have occasionally been found, but not in quantity sufficient to render certain their mineralogical determination.

On a recent visit to these mines Mr. Rodman obtained a considerable number of specimens, lining pockets in the ore, which had the usual brilliant metallic luster on the interior surface, and showed on the fracture a fibrous structure, but differed from brown hematite in having a decidedly red color, and in affording when pulverized a red powder, closely resembling that of ordinary red hematite. This red layer was in some cases an inch or more in thickness, and was deposited on a bed of limonite (brown hematite); the line of demarcation between the brown and the red ore was so perfect, in most instances, as to readily admit of a complete separation of the two minerals.

An examination of this red ore showed it to be an oxyd of iron, containing not far from five per cent of water, a number of specimens yielding very uniform results; and a complete analysis proved the mineral to be a ferric hydrate with the formula $Fe^2\dot{H}$, identical with the *Turgite* of Hermann,* and with Breithaupt's *hydro-hematite*, as analysed by Fritzsche.† The physical characters are so nearly those of ordinary anhydrous hematite that it is difficult to distinguish the species without having recourse to an estimation of the loss on ignition. The turgite yields an abundance of water when heated in the closed tube, and it decrepitates in a remarkable manner. Hardness, about 5·5. G.=4·14. For analysis the mineral was carefully dried over sulphuric acid until of constant weight, and this dessicated mineral was then heated for several hours in an air bath at 100° C. without showing any further diminution of weight. The amount of hygroscopic moisture abstracted from the air-dried mineral by treatment in the dessicator was 1·40 per cent. The iron in one instance was determined by titration with permanganate of potash; in the second case it was thrown down by ammonia, the precipitate washed, dried and weighed, and then the iron was separated from the silica and alumina by Deville's

* Journal für praktische Chemie, xxxiii, 97.

† Breithaupt, Vollständiges Handbuch der Mineralogie, iii, 846.

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method by first reducing with hydrogen, and subsequently volatilizing the iron by heating in a current of dry hydrochloric acid gas. The analytical results were all obtained by Mr. Rodman. Composition:

	1.	2.	Mean.
Ferric oxyd,	91·45	91·29	91·36
Manganic oxyd,	0·67	0·55	·61
Alumina,	0·75	....	·75
Silica,	0·22	0·24	·23
Phosphoric acid, sulphuric acid and cobaltic oxyd,	traces	....	traces
Insoluble in acid,	1·83	....	1·83
Water,	5·20	5·21	5·20
	100·12		99·98

Other determinations of water on different specimens gave 5·02 and 5·09 per cent.

Five grams of the mineral yielded only minute traces of sulphuric acid, and three grams showed but an unweighable trace of phosphoric acid. A very perceptible trace of cobalt was found even on examination of one gram of the mineral. The portion insoluble in acid proved on analysis to consist entirely of silica, and excluding this, with the small amount of silica and alumina found in the soluble portion, the result of the analysis is

	$\dot{Fe}$ 94·00	$\dot{Mn}$ 0·68	$\dot{H}$ 5·35 = 99·98
Oxygen,	28·20	0·19	4·75
	28·39		

giving the oxygen ratio 6 : 1 or $\dot{Fe}^2\dot{H}$.

This result confirms the conclusions of Hermann and Breithaupt that there is a native ferric-hydrate with one-half an equivalent of water. Several years since the attention of the writer was called to this subject by Prof. W. T. Roepper, of Bethlehem, who stated that he had found Breithaupt's hydrohematite to be of frequent occurrence with the limonite ores of the Lehigh valley. A water determination on the Lehigh mineral made by Prof. Roepper, and kindly communicated for this article, gave 5·34 per cent, and Prof. Roepper calls especial attention to the characteristic decrepitation of this mineral when heated. On examination of the specimens of limonite in the Yale College collection, a fine specimen of the red hydrate was found occurring with the limonite of Düsseldorf in Prussia, this yielded on examination by Mr. Rodman 4·75 pr. ct. water. Another specimen was found from Ioditz in Bavaria, besides numerous specimens from Salisbury in Connecticut. A mineral of like composition has also been found by Bergemann* at the Louisa Mine near Horhausen in Prussia. From these numerous

* Rammelsberg, Handbuch für Mineralchemie, 988.

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localities it would appear that the mineral is of common occurrence. It has heretofore been confounded by most mineralogists with hematite which it so strongly resembles in physical characters. It may be readily distinguished from hematite by simply heating a fragment in the closed tube, when it decrepitates violently and gives off a large amount of water.

Hermann does not give the pyrognostic characters of *turgite*, but Breithaupt in his description of *hydro-hematite* makes particular mention of its characteristic decrepitation when heated. The turgite is described by Hermann as being associated with copper ores; its chemical composition is however identical with hydrohematite, and as it has priority of publication the species must bear the name of turgite, and hydrohematite be used only as a synonym.

We have therefore three well defined hydrates of iron occurring native and forming three distinct and well-established mineral species, differing from each other in physical characters and in their relative content of water.

Turgite,	$\dot{\mathrm{Fe}} + \frac{1}{2}\dot{\mathrm{H}}$
Göthite,	$\dot{\mathrm{Fe}} + \dot{\mathrm{H}}$
Limonite,	$\dot{\mathrm{Fe}} + 1\frac{1}{2}\dot{\mathrm{H}}$

Two other hydrates have been described containing respectively two and three atoms of water. Murray* found in a brown iron ore from Hüttenrode in the Hartz—

$\dot{\mathrm{Fe}}$ 81·41, $\dot{\mathrm{H}}$ 17·96, $\ddot{\mathrm{Si}}$ 0·17, Carbon 0·46=100, giving the formula $\dot{\mathrm{Fe}}+2\dot{\mathrm{H}}$.

A compound of similar composition from Kilbride in Ireland, having a pitchy color, analyzed by Haughton, gave—

$\dot{\mathrm{Fe}}$ 77·15 $\dot{\mathrm{H}}$ 20·43 $\ddot{\mathrm{Si}}$ 0·30 $\ddot{\mathrm{Al}}$ *tr.* $\dddot{\mathrm{P}}$ 1·60 = 99·48

Xanthosiderite also appears to be a mineral of like composition, but its mixture with a silicate of unknown composition renders it difficult to conclude positively that it belongs here.

A. H. Church† has analyzed a stalactite of a rust-colored ferric hydrate from Botallack mine in Cornwall, which gave—

$\dot{\mathrm{Fe}}$ 73·73, $\dot{\mathrm{H}}$ 24·40, loss, $\dddot{\mathrm{P}}$, and organic matter 1·76 = 100, giving the formula $\dot{\mathrm{Fe}} + 2\dot{\mathrm{H}} = \dot{\mathrm{Fe}}$ 74·77, $\dot{\mathrm{H}}$ 25·33.

Other analyses of ferric hydrates by many different analysts, and from a great range of localities, give an amount of water which correspond to one or the other of these last two hydrates; but as these contain also either organic matter, phosphoric acid, or silica in the combined state, it is impossible, without further investigation, to know to what hydrate to refer them.

The artificial ferric hydrate precipitated by ammonia from ferric chlorid varies in composition according to the method of

* Rammelsberg Mineralchemie, 150. † Journ. Chem. Society, II, iii, 214.

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treatment. Schaffner obtained a hydrate with 1 atom, Gmelin with 2 atoms, and Wittstein with 3 atoms of water; this last kept for some time under water became crystalline and was converted into a hydrate with 1½ atoms of water. Recent investigations by E. Davies* show that the ordinary precipitated ferric hydrate loses water on being boiled in water; in one case the amount of water was reduced to 3·52 per cent. Similar experiments conducted in this laboratory by Mr. Rodman showed that by continued boiling in water the amount of water remaining in the hydrate could be reduced even to 2 per cent. These facts, as Mr. Davies suggests, explain in a very satisfactory manner the association of the different ferric hydrates in nature and do not necessarily demand the supposition of great heat to account for the large beds of anhydrous hematite found in different parts of the world.

Sheffield Laboratory, February, 1867.

Art. XXIII.—*On a new Test for Hyposulphites;* by M. Carey Lea.

In an examination of the platinum metals which I published some time back in this Journal, I described a very delicate test for ruthenium, by which the faintest traces of that metal could be detected through the agency of hyposulphite of soda. Recently, having occasion to test for the last-named substance, it occurred to me as probable that ruthenium might be rendered available for that purpose. This I found to be the case, and that the reaction exhibited considerable delicacy. It is true that ruthenium is at present a very rare metal, and not within the reach of all who might wish to use it, but the changes from rarity to more or less abundance are now so common and sudden that present scarcity is no reason for ignoring any useful reagent.

When a solution of ruthenium is rendered alkaline by ammonia and boiled with hyposulphite of soda, it gradually assumes a rose color which passes into a rich carmine; with strong solution the color is so intense as to be almost black. When diluted the shade is magnificent, rivalling the aniline red in richness.

I have already stated within what limits ruthenium can be detected by hyposulphite of soda. I now subjoin the limits observed with respect to hyposulphite of soda.

A solution containing one four-thousandth of hyposulphite, gave a clear rose red.

* Journ. Chem. Society, II, iv, 69.

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One containing one twelve-thousandth gave a well marked pink liquid.

One containing one twenty-five-thousandth gave a salmon color.

The experiment was not carried further because the salmon color in the last-mentioned trial showed that the test had then reached its practical limit. I do not doubt that even with one hundred thousandth a coloration could be obtained, but it would not have the specific distinctness given by the carmine and rose shade previously described.

A few words remain to be said as to the best mode of applying this test.

I have recognized in solutions of sesquioxyd of ruthenium a strong tendency to decompose by dilution: dilute solutions have a strong tendency to gradually deposit their ruthenium as oxyd. And even before the slightest sign of a precipitate appears, in fact immediately upon dilution, solutions show a tendency to change their reactions. So that I find it invariably better on diluting the ruthenium solution for use in testing, to boil it (as I have elsewhere pointed out in speaking of the dilution of ruthenium) with a few drops of hydrochloric acid, and this even although the solution is to be immediately afterward rendered alkaline by ammonia. To ascertain with certainty that this improved the delicacy of the reaction, I made comparative experiments on two portions of the same ruthenium solution, and found that the coloration by hyposulphite was at least three times stronger in the case of the portion that had been boiled with HCl than with that that had not.

As ammonia was thereafter immediately added, it might appear that the function of the hydrochloric acid was to form hydrochlorate of ammonia. But it was found by experiment that the addition of sal-ammoniac in no way aided the reaction.

The addition of ammonia to a hot solution of sesquichlorid of ruthenium immediately darkens it to a blackish olive color, which, according to the dilution and the light that falls on it, is of a reddish or a greenish shade. By standing, the ruthenium is precipitated as oxyd. As this condition is the necessary preliminary (as before explained) to the production of the characteristic carmine reaction, it is not a little singular that the delicacy of that reaction should be so greatly enhanced by taking steps to strengthen the combination with excess of acid and boiling, immediately before the affinities are to be loosened by ammonia.

In using this reaction for the detection of small quantities of hyposulphite, it is useful to remark that it succeeds best when very little ruthenium is present. After the ruthenium solution

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has been boiled with acid and supersaturated with ammonia, and the liquid to be tested for hyposulphite added, the mixed solution should have so little ruthenium in it as to exhibit only a very pale transparent olive coloration—should in fact be *almost* without color. Otherwise if the hyposulphite is present in mere traces, we get a salmon or flame color instead of the pure carmine.

ART. XXIV.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. 4.—*On a new mineral from Rockport, Mass.;* by W. J. KNOWLTON.

IN the March number of this Journal for the present year, Prof. J. P. Cooke has described as malacone a mineral discovered by myself at Rockport, Mass., where it occurs in the granite in veins of massive quartz and feldspar. Prof. Cooke's analysis was made, as he states, upon a small quantity of material and he speaks of it as "imperfect"; he found

Silica,	27·90
Zirconia,	66·93
Sesquioxyd of iron, with trace of manganese,	2·57
Water,	2·19
	99·59

which results, if correct, would unquestionably identify the mineral with malacone. I have repeatedly analyzed this mineral, and my results differ, as will be seen, so much from those of Prof. Cooke, and from the analyses of malacone hitherto published, that I am disposed to consider the mineral as a new species. If this conclusion be admitted, I propose for it the name of *Cyrtolite*, (from κυρτος, *curved*,) in allusion to the very marked curvature of the terminal faces which is observed in the great majority of specimens. The mineralogical characters of cyrtolite have been already described by Prof. Cooke. It is almost always found imbedded in massive feldspar, sometimes in large aggregates of crystals, sometimes in single crystals which are often quite perfect. Fine single crystals are found at various places on the sea-shore where the veins have been exposed by the action of the water. The luster of the crystals is often brilliant, but fracture exhibits a dull brownish-red color. In three determinations of the specific gravity of cyrtolite by Rose's method, I found 3·850, 3·856 and 3·970; the last determination being made upon a specimen from a somewhat different locality, and taken from the surface rock near the shore.

Before the blowpipe cyrtolite glows brilliantly, and is but slightly altered in color. Its powder dissolves rather easily in

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borax, giving a distinct reaction for iron. With microcosmic salt it dissolves partially, leaving a white siliceous skeleton. Prof. Cooke states that the mineral is easily and completely resolved by fusion with alkaline carbonates. I have not obtained the same results, but have on the contrary found it very difficult to decompose it completely in this manner; even fusion for several hours with four times the weight of a mixture of carbonate of potash and carbonate of soda failing to produce a perfect resolution. Four consecutive fusions with the alkaline mixture gave but little better results. In another analysis, after fusing for three hours with the alkaline mixture, treatment of the fused mass as an ordinary silicate with chlorhydric acid, and fusion of the silica obtained a second time, there remained 2·20 per cent of earth which could not be further purified by treatment with fluorid of ammonium and sulphuric acid.

When heated with sulphuric acid in a closed tube for two or three hours to a temperature of 210° C., about 33 per cent of undissolved matter remained. On diluting, filtering and boiling the filtrate, from 8 to 13 per cent were precipitated in different experiments, according to the quantity of free sulphuric acid in the solution. When fused with bisulphate of ammonium the mineral is completely decomposed, but it is difficult to avoid loss by spattering. Bisulphate of potash also completely resolves the mineral by fusion, but forms with the zirconia the well known double sulphate which dissolves with much difficulty; bisulphate of soda would doubtless be preferable, but I have not employed it in quantitative analyses. The mineral is more readily resolved by fusion with fluorid of ammonium and subsequent treatment with sulphuric acid. The decomposition is perfect, but of course the silica must be estimated by loss. In four analyses I obtained the following results:

	No. 1.	No. 2.	No. 3.	No. 4.
Silica,	26·29	26·37*	26·48*	26·18
Zirconia,	61·33	61·00	60·00	64·60†
Cerium metals,	2·24	1·80	2·19	1·40
Iron, FeO,	3·65	3·63	3·60	....
Uranium, Ur_2O_3,	....	1·94	2·83	1·40
Tin, with trace CuO,	·35	·70	·35	·41
Water,	4·58	4·55	4·55	4·58
Trace manganese and magnesia,	....	....	....	....
Trace of fluorine,	....	....	....	....
	98·44	100·00	100·00	98·97

In these analyses the water was determined by heating the

* Silica estimated by difference.

† In this analysis the zirconium and iron were not separated.

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mineral in a platinum tube in a current of carbonic acid. The silica was estimated in the first analysis by fusion with bisulphate of ammonia, and in the last by fusion with the alkaline carbonates and subsequent treatment with fluorid of ammonium and sulphuric acid. In the second and third analyses, it was determined by loss. Tin and copper were precipitated by sulphydric acid gas. After oxydizing the iron, the iron and zirconia were precipitated together from the nearly neutral solution by acetate of soda. The iron was then separated from the zirconia by Deville's method for the separation of iron and alumina.

In the filtrate from the iron and zirconia, the cerium metals were precipitated by oxalic acid, and the uranium by ammonia. It is not easy to determine in what state of oxydation the iron and uranium exist in the mineral. I have taken the iron perhaps arbitrarily as protoxyd and the uranium as sesquioxyd. In the second and third analyses the uranium was not perfectly separated from zirconia.

It scarcely admits of a doubt that the zirconia in cyrtolite is associated with another and similar oxyd—perhaps titanic acid. When the zirconia is strongly heated in a platinum tube in a current of hydrogen gas the earth assumes a bluish color resembling that seen in niobic and titanic acids when similarly treated. The color disappears on heating the blue mass in the air. If we add to an acid solution of zirconia from cyrtolite—a solution of the earth in fluohydric acid is best—sodium amalgam, magnesium or zinc, a purple or dull violet color is soon observed, sometimes with a precipitate of the same color. In the absence of any method of separating zirconia from titanic acid, &c., quantitatively, I must leave the precise constitution of the metallic acids in cyrtolite undetermined. I am very far from supposing that my analyses of the mineral leave nothing to be wished, but in the absence of good and thoroughly tested methods of analysis, I have done all in my power to obtain correct results.*

Cambridge, June 29th, 1867.

Art. XXV.—*On the subdivisions of the Cretaceous rocks of California;* by Wm. M. Gabb.

Since the publication of the first volume of the California Reports on Paleontology, there have appeared several rather severe, and not altogether good natured criticisms. These have culminated in the publication by the Smithsonian Institution of

* I may be permitted to mention in this connection that I have found cæsium in the cryophyllite from Rockport, described by Prof. Cooke. The alkali is easily detected by the spectroscope in the alums obtained from the mineral, but its quantity is very small—much less apparently than that of rubidium.—W. J. K.

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a pamphlet purporting to be a check list of Eocene fossils, prepared by one of our oldest Paleontologists. So eminent an authority and the endorsement of so respectable an institution require that I should say something in vindication of the position I have taken, and give to the scientific world the grounds on which I base my deductions.

The rocks of California, included by the Geological Survey under the general head of Cretaceous, can be easily separated into two well-marked divisions. Our acquaintance with them has not yet been sufficiently detailed to attempt a further separation into sub-groups, though, in the older members, that can doubtless be done hereafter. This older group is without doubt the equivalent of the No. 5 and the upper part, if not the whole of No. 4 of Meek and Hayden's Nebraska section. There may be, and in fact probably are, older members of the Cretaceous formation represented in California, but our information is, as yet, too limited to make the assertion positively. In the northern part of the state, where these rocks have been least studied, isolated specimens have been obtained with a decidedly "Neocomien" aspect. The more recent member, always conformable with the lower, and connected with it by a series of strata not very fossiliferous, appears to be the American representative of the Maestricht beds, the 'Danien' of the French authors. The position of the older group is universally conceded, and it only rests with me to establish that this newer group is without doubt Cretaceous and not Eocene as Mr. Conrad originally asserted and still maintains.

It has many points in common with the Maestricht beds of Europe. It contains but a single species, so far as known, of the complex-chambered group of Cephalopods. A solitary ammonite, represented by half a dozen specimens, has been found by myself, in place, even to the very top of the formation.

The rocks which I included in my Division B, are found in and more particularly along the eastern face of the Coast Ranges over an extent of upwards of four hundred miles. They are in many places metamorphosed, but are in a number of localities highly fossiliferous. The principal localities from which fossils have been collected are—the vicinity of Fort Tejon, New Idria, near Griswold's on the road between New Idria and San Juan, Clayton at the Monte Diablo coal mines, Martinez, San Diego and on one of the forks of Eel river near Round Valley, Mendocino county. At Clayton and Martinez they are connected with Division A by a regular succession of intermediate beds but containing very few fossils. Near the village of Lower Lake, Lake county, these intermediate beds are again developed and are then highly fossiliferous.

In the California Cretaceous rocks we have already recog-

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nized and described 280 species, besides about fifty species not yet described but of which we have sufficient material for publication, and about 30 or 40 species, the existence of which is indicated by fragments too imperfect for description. Of these species 107 are found in Division B. Of these 107, 84 are, so far as known, peculiar to this group, and 16 are found in common in undoubted members of both divisions, while 7 more are found in the intermediate beds associated with a nearly equal number of representatives of the lower group. Thus the two groups are connected by a passage of nearly one-fifth of all the species found in the upper member.

The following analysis will prove the above statements more clearly.

Of the 107 species of fossils found in Division B, 44 are found at Clayton, 67 at Tejon, 54 at Martinez, 22 at San Diego, 18 near Griswold's, and 7 near New Idria. It is not intended to be understood that these are all of the species found at these localities; but that, up to the present time, these are all that have been identified or described. Future work will undoubtedly change the above figures.

Of the species found at the above localities, 50 are peculiar to one or another locality; 29 are found at two localities only, 14 at three localities, and 14 at four localities or more.

Taking the three typical localities, Martinez, Clayton and Tejon, 21 species are common to Martinez and Clayton, 30 to Martinez and Tejon, 25 to Clayton and Tejon, and 20 are found at all three localities.

As I have stated above, 16 species found in the upper member also extend into the older group, Division A. In addition to this, at the locality near Lower Lake Village, Lake county, besides several species encountered for the first time, I found 15 species in the same bed, within a superficial area of two feet. Of these, 3 were previously known to be common to the upper and lower division. Besides these 3, 7 of them were common to this locality, and localities of division B; and the remaining 5 were, before this discovery, considered peculiar to the lower member. One of these 5 is found in the Mississippi Valley, in the "Ripley Group," and another belongs to a peculiarly Cretaceous genus.

As to the species found at the several typical localities, independent of each other, and which would serve to show their individual relations to the older formation without corroborative evidence, Clayton has 10 species in common with Division A, Tejon has 7, and Martinez 11. With the Lower Lake bed, Clayton has 5 species in common, Tejon 5, and Martinez 6.

In glancing over Mr. Conrad's "check list" I find that out of the 107 species found in his "Older Eocene of California," he

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has only included 74 in his enumeration. He has omitted *Callianassa Stimpsonii*, Ammonites n. s., *Nautilus Texanus*, *Cylichna costata*, *Mactra Ashburnerii*, *Cucullæa Matthewsonii*, *Nucula truncata* and *Leda protexta;* eight species, which I mentioned in the Journal of Conchology (vol. ii, p. 88), as being found in common in the two members of the California Cretaceous, stating distinctly the localities in which they have been found. At the same time he includes five other species, from the same list, in his Eocene catalogue. Whether this be carelessness, or an unfair avoidance of a difficulty, I leave to others to decide. It is far easier to ignore such a difficulty than it is to explain it away.

In regard to the distribution of the genera and species in this and the associated rocks: all of the species are peculiar to this group, or to this and *underlying* rocks; *not one* has been found associated either with living forms, or with species known to occur in the recognized Tertiaries of California. Five of the genera are peculiar to the Secondary. An Ammonite ranges entirely through the group to the top of the highest fossiliferous strata. The genera *Perissolax*, *Gyrodes*, *Margaritella*, and the sub-genus *Anchura*, of the genus *Aporrhais*, are all recognized as strictly characteristic of the Cretaceous; so much so, that the presence of a single undoubted representative of either of these genera would be strong presumptive evidence of the Cretaceous age of any rocks in which it might be found. On the other hand, the presence of such genera as those in the list given below, would point to a very modern era in the Cretaceous, to say the least.

It must be borne in mind that we have much to learn yet in paleontology, especially in the matter of the vertical range of genera. Every year we find genera, nay, whole families, extending themselves beyond what had been fixed by previous authors as their limits. A few years ago, the presence of mammalian remains was considered characteristic of the Tertiaries. Now we know of Marsupials in the Trias, and who dare say that we may not find mammals in Paleozoic rocks? I therefore maintain, that though we have here such genera as Aturia, Typhis, Cordiera, Pseudoliva, Nassa, Mitra, Ficus, Morio, Cerithiopsis, Cypræa, and Galerus, still, the only inference that can be drawn is, that the group is on or near the verge of the formation, a sort of prophetic member, presaging by some of its genera the formations to come, but indissolubly bound by specific ties with the eras preceding.

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ART. XXVI.—*On a new apparatus for technical analysis of Petroleum and kindred substances;* by S. F. PECKHAM.

IN the Chemical News for August 31st, 1866, I noticed a paper in which was described a process with apparatus, for the assay of coals and other substances yielding illuminating and paraffin oils.* After stating the fact, that no process had hitherto been described by which technical analyses of bituminous and pyro-bituminous substances could be made to yield analogous and satisfactory results, the author proceeds to describe what I should suppose to be a very valuable process for the primary distillation in the technical analysis of coals and shales. I do not repeat the description here, as it would require considerable space, and it can only be applied to the treatment of solid substances, which do not melt at a temperature below that required for their distillation. As the original paper is easy of access, I would recommend its perusal to all who wish to make technical analyses of either coals or shales. The apparatus is simple and inexpensive, and I am aware of no reason why the results furnished by it should not prove highly satisfactory, especially as its operation bears a striking resemblance to the most improved processes of manufacture on the large scale.

But beyond the primary distillation of the coal or shale, I do not consider that our author has added anything to processes long in use. When he arrives at the second distillation, or that which corresponds to the primary distillation of petroleum, he is forced to return to the old process of fractional distillation from a common tubulated glass retort. This process is not only very unsatisfactory in its results, but it is quite expensive, and is attended with considerable danger from fire. It is unsatisfactory, because the separation of fluids of different densities and different boiling points, is much less complete than by Warren's process, for any temperature below the boiling point of mercury; in fact, for any temperature necessary to ensure the complete separation of the light oils usually called naphtha, and the "photogen" or illuminating oil.† It is expensive, for the reason that if the distillation is conducted to dryness the retort is sacrificed, as it is rarely possible to remove the coke with safety. It is attended with danger from fire, because the best retorts are liable to fracture from the high heat to which they are exposed, even when the greatest care is exercised in conducting the operation.

* On the Assay of Coal, etc., for Crude Paraffin Oil, and of Crude Oil and Petroleum for Spirit, Photogens, Lubricating oil and Paraffin, by John Attfield, Ph.D., F.C.S., Director of the Laboratory of the Pharmaceutical Society of Great Britain. Chem. News, vol. xiv, p. 98.

† For details of this process, see Mem. American Academy, N. S., vol. ix, Chem. News, vol. xii, p. 85.

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I was about to commence a technical examination of several specimens of California petroleum, when the above mentioned paper arrested my attention, and I was unpleasantly conscious when I had finished its perusal that in respect to apparatus for this department of research my want was just as far from being supplied as it was six years since, when I commenced the study of petroleums. I had but a small quantity of each specimen, and besides subjecting them simply to fractional distillation, I wished to test them by Young's process of distillation under pressure. To conduct the latter process in glass was an impossibility.

To answer my purpose therefore, my apparatus must fulfil the following conditions. It should be capable of working not more than one and one-half liters, and admit of being heated by an ordinary gas furnace. The joints should sustain a pressure of forty pounds per square inch, and it should be so constructed as to admit of the ready extraction of the coke. I could find no description of any such apparatus, but after numerous failures and corrections, in an apparatus of my own invention I found my want so well and fully supplied, that I am led to offer a description, for the benefit of those who, like myself, have felt the need of such an instrument.

Upon each extremity of a piece of a wrought iron gas-pipe, three inches in diameter and twenty inches in length, a cap is securely screwed. The caps should be heated nearly to redness and screwed on to the cold pipe in order that by their contraction they may be more firmly secured. The pipe is then put in a lathe and the caps turned off in such a manner as to leave a band upon each end of the pipe, about three-fourths of an inch in width, and two circular discs of iron, each about four inches in diameter, and one-fourth of an inch in thickness, having a projection upon one of their surfaces to which a wrench may be applied. The edges of each extremity of the pipe with the bands are now carefully turned off, presenting smooth surfaces slightly beveled inwardly. The plane surface of each of the discs is then so turned off upon its circumference, that it will exactly fit the beveled edge of the pipe. This completes the retort.

A stout parallelogram is then made half an inch longer and wider than the retort, one of the shorter sides of which should contain in the middle a stout set-screw, and the other an orifice made to fit the projection upon the disc. This may be called the frame.

Two holes are then drilled a short distance from either extremity of the retort, and in a line parallel to the axis of the retort. One of these should admit a half inch, and the other an inch gas-pipe. With this arrangement the retort may be used either for pressure distillation, or for distillation by the ordinary process. It also admits of being connected with an apparatus

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for furnishing superheated steam or carbonic acid gas, either of which are sometimes used to assist the distillation of hydrocarbons. Both the goose-neck and valve should be connected with the retort by a short piece of gas-pipe and a brass "union" or coupling, as the difference in the expansion of brass and iron would cause a joint of the two metals to leak very badly when subjected to a high temperature. The goose-neck may be made of the ordinary form, tapering from one inch to one-quarter inch, and about ten inches in length. The material should be copper, brazed. The valve will be described hereafter.

In order to use the retort, one of the discs is luted with a very thin paste of plaster of Paris and firmly pressed into its seat. The retort is then slipped into the frame and left a moment for the luting to set, the open end being uppermost. The oil is next poured in and the other disc luted into its seat, the frame adjusted and the set-screw firmly set up, so as to securely fasten both discs in their places. The goose-neck or valve is then adjusted, and the connections made with the worm and receiver. It will be observed that all the expansion that takes place in this retort only brings the different portions of the apparatus more firmly together, instead of causing them to crack apart and leak with every slight variation of temperature, as is usually the case. With this arrangement I was able to distill fifteen hundred cubic centimeters of petroleum to dryness, the last portions coming over at a red heat. The distillation was commenced with two ordinary Bunsen's gas lamps, increased as required to four, and toward the end of the operation to six—the latter number being sufficient to bring the side of the retort in contact with the flame to a bright cherry-red heat.

Any one who has attempted the distillation of small quantities of petroleum in either iron or copper stills, or retorts of whatever form, inbedded in coal fires or suspended over them, must be aware of the difficulty of so regulating the fire as to secure a constantly increasing heat from the beginning to the end of the operation. No such difficulty is experienced with this apparatus. In it the lightest oils may be distilled by means of a sand-bath, and the heaviest by applying the flame of a sufficient number of lamps directly to the retort. The joints of this apparatus when luted with the smallest possible quantity of finely pulverized calcined sulphate of lime, admit of the least loss by leakage of any metallic retort that I have ever used. With the exercise of proper care the amount of distillate from California petroleum averaged above ninety per cent by measure, and with a pressure of thirty pounds per square inch the average was eighty-seven and one-half per cent. In the latter instance the loss was increased by the formation of gas and vapors that passed through the worm uncondensed at 8° C. The largest

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amount of distillate that I have seen recorded, as yielded by any material of undoubted natural origin, is ninety-five and one-half per cent, by measure.* The distillation of which this was the product was performed wholly in glass, without pressure, the crude material being a California petroleum of medium density, yielding no permanent gases and no naphtha. In this case the loss may be estimated at zero. I think it will be readily conceded, that any apparatus which admits of the ready extraction of the coke, and at the same time yields an average of ninety-two and one-half per cent of distillate, furnishes results far more satisfactory than any hitherto in use for operating upon so small a quantity as fifteen hundred cubic centimeters.

A thermometer may be inserted in the smaller orifice, for noting the temperature at which light oils distill. A piece of gas-pipe of the requisite size and about two inches in length may be used for making the connection, the thermometer being luted into one end of it. When but one of the openings in the retort is in use, the other may be closed with an iron plug.

In making my experiments upon Young's process of distillation under pressure, I experienced much difficulty in contriving an apparatus that would enable me to register the amount of pressure, and at the same time prevent any loss of vapor. I first attempted to register the pressure by means of a U tube, the arms of which were of unequal length. The tube was filled with mercury to a level with the shorter arm and the long arm sealed with a column of air above the mercury. The pressure was indicated by the rise of mercury in the longer arm and consequent compression of the air, the shorter arm being in communication with the retort. The escape was badly regulated by an ordinary stop-cock. The very unequal expansion of glass and iron prevented me from making a tight joint between the retort and U tube.

I next tried a small valve constructed like an ordinary safety valve. I found it impossible with this valve to prevent a large amount of loss from escape of vapor around the spindle.

I next tried a loaded valve, the load of which was placed directly upon the spindle, the whole contained in a chamber resembling a miniature steam-chest, from which the vapors could only escape into the worm. It was found upon trial with the safety-valve that an orifice three-eighths of an inch in diameter was too large in proportion to the size of the retort, the vapors escaping in too large volume to admit of a continued flow from the worm. The vapor escaped in intermittent puffs, thereby causing an undulatory movement from the requisite amount of pressure to no pressure at all. As a consequence, the results

* Report of C. M. Warren, Esq., contained in an article on Petroleum in California, by Prof. B. Silliman, National Intelligencer, Feb. 7th, 1866.

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rendered were very imperfect. To obviate this difficulty, I made the orifice beneath the valve only one-sixteenth of an inch in diameter, the surface of the orifice being to that of the retort as one to sixty thousand. This arrangement enabled me to secure a constant flow of vapor from the retort, to maintain a constant pressure, and to preserve a constant degree of temperature. I found by computation that a pressure of two ounces avoirdupois upon an orifice one-sixteenth of an inch in diameter was equivalent to a pressure of forty pounds to the square inch, yet when I placed a weight of two ounces upon the spindle, which of itself weighed half an ounce, the steam gauge registered only ten pounds, and the oils passed through it unchanged in density. Although I employed one of the most skillful workers of brass in this city to grind the valve, I am satisfied that the fault was in the mechanical execution of the work, and that the bearing of the valve was upon the side of the cone instead of at its apex, leaving a minute cavity beneath the valve. This fault could only be remedied by increased pressure. The chamber being too small to admit of placing the requisite weight upon the spindle, I made use of a spiral spring, the force of which was adjusted by an ordinary steam-gauge. By this means I was enabled to obtain the required pressure and to estimate its amount, with but one source of error, viz., the diminution in the elasticity of the spring incident to the high temperature of the vapors of the oil. I am convinced that the amount of this diminution is considerable; I have estimated it at one-fourth. The original elasticity returns, however, as soon as the spring is cold.

The following is a description of the valve as finally arranged. A piece of wrought iron gas-pipe one inch in diameter and three inches in length is bored out true, and an orifice drilled in its side one and one-fourth inches from the upper end, into which is brazed a piece of quarter inch gas-pipe about three inches in length. Both ends are now turned off and threads cut upon them, to which are carefully fitted strong brass caps. The upper cap should be about three-quarters of an inch in thickness, perforated two-thirds through from the inside with an eighth-inch drill, the orifice to serve as a guide to the upper end of the spindle. There should be a nipple three-fourths of an inch in length upon the lower cap, to connect it with the retort. The cap should be about one-half an inch in thickness, and with the nipple, should be perforated with a sixteenth inch drill. The seat of the valve should be excavated in the inside of the lower cap. A diaphragm should be placed within the iron tube, one inch from its lower end to serve as a guide for the spindle, through the center of which the spindle should pass, while around it should be numerous small openings to allow for the free passage of the vapor. The valve itself should be turned upon the end of a spindle three-sixteenths of an inch in diameter,

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and carefully ground into its seat. The length of the spindle should be one-fourth of an inch less than the distance from the seat of the valve to the bottom of the orifice upon the inside of the upper cap, when both caps are in position. This allows the spindle to lift well, with sufficient room for the passage of the vapors. The diameter of the spindle should be reduced to one-eighth inch above the diaphragm. A spiral spring, of a diameter nearly equal to the interior of the pipe, made of brass wire about one-sixteenth of an inch in thickness, is so adjusted that the valve would be raised against the elastic force of the spring. This is effected by gradually reducing the diameter of the coils of the lower end of the spring to one-eighth inch, when it will just rest upon the shoulder upon the spindle. The upper coil of the spring should just touch the inside of the upper cap, when it is firmly screwed up. It will thus be seen that a force sufficient to cause the spring to contract one quarter of an inch is equal to a direct pressure upon the valve of two ounces. This pressure may be regulated by an ordinary steam gauge, the force depending for the same length of spring and size of wire upon the *number* of coils employed.

With this apparatus and the one described by Mr. Attfield, small quantities of every variety of bituminous and pyro-bituminous substance, may be subjected to treatment analogous to the most improved processes now in use upon the large scale. The results are reliable and admit of ready comparison. The cost of the retort with goose-neck and valve, made by the most skillful workmen, is about twenty-five dollars.

The annexed diagrams give a section of both the valve and retort.

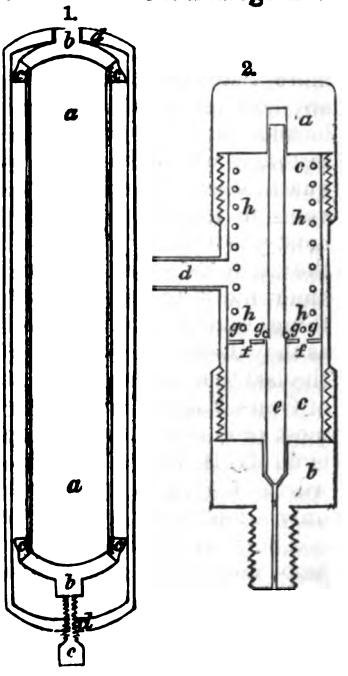

Fig. 1 represents a horizontal section of the retort, one-fourth the size; in which *a a* is the gas-pipe; *b b* are the discs; *c c c c* are the bands left when the caps are turned off; *d d* is the frame and *e* the set-screw.

Fig. 2 represents a vertical section of the valve, of full size, in which *a* represents the upper cap, *b* the lower cap, *c c* the gas-pipe, *d* the escape pipe, *e* the spindle, *f f* openings in the same for passage of vapors, *g g g g* the diaphragm, and *h h h h* the spiral spring.

Providence, R. I., April 30th, 1867

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ART. XXVII.—*Notes on the Grass Valley Gold-mining District;* by Prof. B. SILLIMAN.

GRASS VALLEY DISTRICT has obtained a well-earned celebrity as the most prosperous of all the gold-quartz mining districts in California. Quartz mining was begun here as early as 1850, and has been continued with, on the whole, a steadily increasing success, to the present time.

It is difficult to obtain exact statistics of the total product of the Grass Valley quartz mines, but it is believed by those best able to form a trustworthy opinion on this subject, that the product in 1866 was probably not less than $2,000,000, while for the whole period from 1851—say fourteen years—it was probably in excess of $23,000,000.

Wm. Ashburner, Esq., in his remarks on the gold mining interests of California, in J. Ross Brown's Report on the Resources of the States and Territories west of the Rocky Mountains, speaks of the Grass Valley region (page 46) thus:

When we consider the richness of the veins, the length of time some of the mines have been worked, and the amount of gold annually produced, the most important quartz mining region of California is, without any doubt, that of Grass Valley, in Nevada county. Here mines have been worked uninterruptedly since 1851. It is true there have been periods when the interest was more than usually depressed, and several of the mines, which are now regarded as among the best, were thought to be exhausted and were abandoned for the time being, but in many instances where work was resumed new bodies of gold-bearing quartz were opened up, which proved rich and valuable. The veins in this district, and particularly those which have been most productive, are noted for their narrowness, as well as for the richness of the quartz. They are encased in a hard metamorphic rock, and the expenses of mining are, as a general thing, higher here than anywhere else in California, amounting as they do in some instances, to from $20 to $26 per ton. Within the last fourteen years the total production from the quartz mines of Grass Valley District has been not far from $23,000,000. The most prolific vein has been that situated upon Massachusetts and Gold Hills, which alone has produced more than $7,000,000 worth of gold during this time, from a lode which will average only a foot or fourteen inches in width.

The gold bearing rocks at this place are mostly highly metamorphic schists or sandstones passing into diorite or greenstone syenite. These greenstones seemingly crystalline, are probably only highly altered sedimentary rocks, containing a large amount of protoxyd of iron with sulphuret of iron. In some parts of

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the district, slaty rocks occur, more or less talcose or chloritic in character; masses of serpentine also abound, forming at times one wall of the quartz veins. This serpentine is probably metamorphic of the magnesian rocks last named. The red soil, seen almost everywhere in the Grass Valley district, has its origin in the peroxydation of the iron contained in the greenstones and diorites, and set at liberty by their decomposition.

The line of contact between the gold-bearing and metamorphic rocks of Grass Valley, and the granites of the Sierra Nevada is met on the road to the town of Nevada, about half a mile before coming to Deer creek. The talcose and chloritic slates are seen to the north, in the direction of the Peck lode, and in the slate districts of Deer creek.

The dip and strike of the rocks in the Grass Valley region is seen to vary greatly in different parts of the district. Following the course of Wolf creek, a tributary of Bear river, it will be observed that the valley of this stream—which is Grass Valley—as well as of its principal branches, follows in the main the line or strike of the rocks. In the absence of an accurate map of the region, it may not be easy to make this statement evident. But all who are familiar with the chief mines of this district, will recall the fact, that the course of the veins in the Forest Springs location, at the southern extremity of the district, is nearly north and south—N. about 20° E.—with a very flat dip to the east, while at the Eureka mine, on Eureka hill, about four miles to the northward, the course of the vein is nearly east and west, with a dip to the south of about seventy-eight degrees. Again, commencing at North Gold Hill and following the course of the famous vein which bears the names of Gold Hill, Massachusetts Hill and New York Hill, we find the veins conforming essentially to the southerly course of the stream with an eastarly dip. The North Star, on Weimar Hill, has likewise the same general direction of dip. Near Miller's ravine, at El Dorado mill, Wolf creek makes a sudden bend to the left, or east, leaving the Lone Jack, Illinois, Wisconsin and Allison Ranch mines to the west. All these last named mines are found to possess a westerly dip, showing the existence of a synclinal axis running between the base of New York Hill and the mines having westerly dips last named, along which probably the veins will, if explored in depth, be found "in basin." The dip at Lone Jack is about 30° W., at Allison Ranch it is about 45° W. Just below the Allison Ranch mine, Wolf creek again makes a sharp turn to the left, nearly at a right angle, and then resumes its former course with the same abruptness. A mile lower down, where it strikes the Forest Springs locations, we find the Norambagua inclosed in syenitic rocks, dipping at a very low angle to the east, a dip seen also at still less angle in the Shamrock,

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yet farther south. There is probably a saddle or anticlinal axis below the Allison Ranch mine, due to the elevation of the syenitic mass, which, it seems probable, sets in at the sharp bend in the stream, before alluded to, and where the ravine trail joins it. The stream probably runs pretty nearly in the basin of the synclinal.

The rocks on the east side of Wolf creek, and above Forest Springs locations, dip westerly. Such is the case at Kate Hayes, and with the veins on Osborn Hill. The middle branch of the creek sweeps around to the east, forms its junction with the north fork, and the veins explored there near its upper waters, as at Union Hill, the Burdett ground, Murphy vein, Lucky and Cambridge, all dip southwest or south, conformably to the Idaho and Eureka, and at a pretty high angle. The Eureka vein going west, faults in the Whiting ground, and having previously become almost vertical has, west of the fault, a *northerly* dip at a high angle. At the Coe ground, this northerly dip is also found at an angle of about 50°. At Cincinnati Hill the vein dips southerly, in a direction exactly opposite to that of the North Star, there being a valley between the two, and a saddle or anticlinal between Cincinnati and Massachusetts Hills.

These facts, which, by a more detailed statement, could be easily multiplied, seem to warrant the conclusion that the course and dip of the Grass Valley vein is especially conformable to that of the rocks, and that the streams have, in general, excavated their valleys in a like conformable manner.

The quartz veins of Grass Valley District are not generally large. Two feet is probably a full average thickness, while some of the most productive, and those which have given, from the first, a high reputation to this region, have not averaged over a foot or possibly eighteen inches in thickness. There are some exceedingly rich veins which will hardly average four inches in thickness, and which have yet been worked at a profit, while at the same time there are veins like the Eureka which have averaged three feet in thickness, and the Union Hill vein over four feet. The Grass Valley veins are often, perhaps usually, imbedded in the inclosing rocks, with seldom a fluccan or clay selvage or parting, although this is sometimes found on one or both walls. The walls of the fissures and the contact faces of the veins are often seen to be beautifully polished and striated.

The veins are, as a rule, highly mineralized and crystalline, and afford the most unmistakable evidence of an origin from *solution* in water, and not the least evidence of an igneous origin. Chalcedonic cavities and agatized structure are very conspicuous features in many of the best characterized and most productive of the gold-bearing veins of this district. These indisputa-

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ble evidences of an aqueous origin are seen in Massachusetts Hill, Ophir Hill, Allison Ranch, Kate Hayes and Eureka.

The metallic contents of Grass Valley veins vary extremely, some carry but very little or no visible gold or sulphurets, although the amount of gold is found in working in mill to be satisfactory, and the sulphurets appear on concentrating the sands from crushing. This is the case in the Lucky and Cambridge mines, for example. But in most cases, the veins of this district abound in sulphurets, chiefly of iron, copper and lead, the sulphuretted contents varying greatly in the same vein; zinc and arsenic are found also, but more rarely. The most noted example of arsenical sulphurets are in the Norambagua and on Heuston Hill; lead abounds in the Union Hill lodes (as galena,) and the same metal is found associated with the yellow copper in parts of the Eureka mine. The gold when visible is very commonly seen to be associated with the sulphurets—this was particularly the case in Massachusetts Hill; while in Rocky Bar and Scadden Flat, on the same vein, the gold is found sometimes in beautiful crystallized masses, binding together the quartz and almost destitute of sulphurets. Mr. William Watt informs me that in working some seventy thousand tons of rock from Massachusetts Hill vein, the average yield of gold was about $80; but at times this vein was almost barren, while again the gold was found in it so abundantly, especially where it was thin, that it had to be cut out with chisels. It is matter of notoriety that in the Gold Hill vein (continuation of the vein in Massachusetts Hill) portions of the lode were so highly charged with gold that the amount sequestered by the miners in a single year exceeded $50,000. On the other hand, in the Cambridge and Lucky mines, yielding about $35 to $60 of gold to the ton, the precious metal is seldom visible. In the Eureka, where the average yield of gold in 1866 was $50 per ton, it seldom exhibited what may be called a "specimen" of gold.

The structure of the veins in Grass Valley varies, in different portions of the district, especially in respect to the distribution of the pyrites and of portions of the adjacent walls. On Eureka Hill, the veins possess a laminated structure parallel to the walls, enclosing portions of the diorite or talcose rocks, forming closures or joints in which the vein splits easily. On these surfaces of cleavage minute scales of gold may often be detected by close inspection. The sulphurets are also seen to be arranged in bands or lines parallel to the walls. In many other cases, this kind of structure is found to be wholly absent, while the sulphurets and gold appear to follow no regular mode of distribution. In a few mines the sulphurets are arranged very distinctly in bands of zones, parallel to the walls, forming "rib-

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bon quartz." This is especially distinct in the Norambagua, where, as before mentioned, the sulphurets are arsenical, and the gold very finely disseminated.

The average amount of gold in the Grass Valley veins is believed to be considerably in excess of what is found in most other portions of California. In Allison Ranch, Massachusetts Hill, Rocky Bar, Ophir Hill, and Eureka, this average has probably reached $50 to the ton. In many other mines it has been considerably less, but on the whole, $30 may not be far from the general average for the whole district; meaning of course, the amount actually saved by milling operations.

The loss of gold is very various, but is probably nearly always greater than owners are willing to confess—if indeed they know, which is doubtful. It is certain, in one well known mine, my own samples of quartz sands, and sulphurets from "pans," assayed respectively $23 and $57 per ton—a result which was later confirmed, quite independently, by the researches of a very competent mining engineer. In other cases, as at Eureka and Norambagua, my own researches show the loss in the tailings to be very small, not exceeding seven dollars to the ton in the latter, and less than that in the former.

The gold in many of the Grass Valley mines is very easily worked, being clean, angular and not very small, hence it is readily entangled in the fiber of blankets, together with a considerable portion of sulphurets, naturally leading to the method most commonly in use in Grass Valley for treatment of the gold ores.

What may properly be called the Grass Valley method of amalgamation consists in the use of heavy stamps, seven hundred or a thousand pounds, crushing usually two tons, sometimes two and a half tons of ore each in twenty-four hours—through screens not exceeding No. 6, rarely so fine. Amalgamating in battery and copper aprons are usually omitted. In some mills, murcurial riffles are placed in front of the discharge, but commonly the whole body of crushed stuff is led at once over blankets, which are washed out every few minutes into tanks where the free gold and sulphurets are allowed to collect preparatory to being passed through the "Attwood amalgamators." These simple machines are designed to bring the gold into thorough contact with mercury contained in little vats sunk in the surface of an inclined table, over which the stuff is fed to the vats in a regulated manner by a stream of water, while iron blades slowly revolve in the vats to cause a mixture of the sands and quicksilver. By this apparatus, at the Eureka mill ninety per cent of all the gold is obtained which is saved from the ore. Beyond the amalgamators, the sands are carried over amalgamated copper sluices, and are put through various ore-

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saving processes with a view especially to concentrating the sulphurets. These processes vary much in different mines. In some mills, especially the Ophir, much more elaborate mechanical apparatus has lately been introduced—with what results still remains to be seen. It is certain that if the method of treatment just sketched seems imperfect, (as it undoubtedly is,) it is the method which has hitherto yielded the large returns of gold for which Grass Valley has obtained its well-deserved renown. As the development of the district goes forward, cases will occur of veins containing gold in a state of very fine division, to which other methods of treatment must be applied. Such examples indeed already exist, and the problems which they offer will be met by the use of other systems of amalgamation, or by suitable modifications of the existing system.

The sulphurets occurring in the Grass Valley District are usually rich in gold—some of them remarkably so. In quantity they probably do not on an average amount to over one per cent of the mass of the ores, although in certain mines they are found more abundantly. For a long time there was no better mode known of treating them than the wasteful one of grinding them in pans and amalgamating. In this way rarely was 60 per cent of the gold saved. After many abortive efforts, at length complete success has been met with in the use of Plattner's chlorination process. Mr. Deetken, now connected with the reduction works of the Eureka mine, is entitled to the credit of having overcome the difficulties which formerly prevented the successful use of this process in Grass Valley, a more detailed description of which will be found in our notice of the Eureka mine.

Of the length of the productive portion of quartz veins and the depth at which they commence to become productive, Grass Valley offers some instructive examples.

The North Star vein, on Weimer Hill, has been proved productive on a stretch of about one thousand feet, while the proportion of gold has gradually increased with the depth, from an average of twenty dollars in the upper levels to nearly double that in the lower levels. The limits named are rather those of exploration than the known extent of the productive ore. In the vein on Massachusetts and Gold Hills, on the contrary, the distribution of the "pay" has been found much more capricious, being at times extremely rich, and again with no apparent reason yielding scarcely the cost of milling. The Eureka mine offers the most remarkable example, however, of a steady increase from a non-paying amount of gold near the outcrop to one of uncommon productiveness. An opinion has found advocates, and has been perhaps generally accepted by most writers on the subject of gold-bearing quartz veins, that they were richest near the

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surface and in depth became gradually poorer. There is nothing in the nature of the case, as it seems to me, to justify such a generalization, more than there is to sustain an opposite opinion. If we accept facts as a guide, we find in California that the deepest mines, for example, Hayward's Eureka, in Amador, 1,200 feet, North Star, 750 feet on the slope, Princeton, in Mariposa county, 800 feet, Eureka (Grass Valley) 400 feet, Allison Ranch, 525 feet, etc., as a rule have an increasing amount of gold. If the Allison Ranch, the Princeton mine, and some others appear to be exceptions, the answer is, we may reasonably expect the same variations of productiveness in depth which are known to exist in linear extent. The Princeton, after an excellent run of good ore, became suddenly poor, at a depth of over six hundred feet, in 1865; but I am informed by Mr. Hall, the present superintendent, that the good ore came in again in a short distance. Mr. Laur, the French engineer, whose papers on California mines is often quoted, cites the Allison Ranch mine in evidence of the theory of a decreasing amount of gold in depth, but it is in proof that since the date of Mr. Laur's visit (1862–3), this mine has been at work on ores which have yielded over one hundred dollars value, its present suspended activity being due to causes quite unconnected with the intrinsic value of the mine. The rich "chimneys," or productive zones of ore ground, are known to be of various extent in quartz veins, from a few feet to many hundreds of feet, and it is impossible to assign any valid reason why we may not expect the same changes in a vertical direction which we find in a horizontal. As the ore-bearing ground or shoots of ore have in many, if not in most cases, a well determined pitch of the vertical, it is self-evident that a vertical shaft, or incline at right angles to the vein must, in descending, pass out of the rich into poor ground, at certain intervals, and it is perhaps due to ignorance of this fact that miners have abandoned sinking because they found the "pay" suddenly cease in depth, when a short distance more would probably bring them into another zone of good ore. The experience of every gold mining district offers examples in illustration of these remarks. In quartz veins containing a considerable amount of sulphurets, it is evident that the outcroppings should offer much better returns to mining industry than will follow after the line of atmospheric decomposition has been passed, because above this line nature has set free the gold formerly entangled in the sulphurets, leaving it available for the common modes of treatment, with the added advantage often times that the particles of free gold formerly distributed through a considerable section of the vein, are found concentrated in a limited amount of ore. It is easy to reach the conclusion in such cases, that the amount of gold in the vein is less in depth,

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after the real average amount is reached, while in fact it is neither greater nor less; but the metal is no longer available by common methods of treatment.

The Eureka mine.—From the date of its location, February 7, 1857, to the close of 1858, the mine proved only a source of expense to its owners, and its history is instructive as suggesting that shallow surface explorations, in gold mining, may be as unsatisfactory as they are known to be in other mining enterprises. So late as 1858, it is said, that five thousand tons of quartz taken above the drain level, or thirty feet from the surface, yielded in mill less than ten dollars per ton in gold, not returning expenses. A shaft sunk to a depth of about fifty feet afforded quartz, however, which yielded about fifteen dollars per ton, and the amount of gold rapidly increased to twenty-eight dollars at one hundred feet. Between the one hundred and two hundred feet levels the average yield was about thirty-seven dollars per ton, and between the two hundred and three hundred feet levels the average has been about fifty dollars per ton, rising to sixty-four dollars in the last four months of 1866.

There are in fact two distinct veins in the Eureka mine, separated from each other by a mass of greenstone or metamorphic sandstone, about twenty-eight or thirty feet in thickness. The smaller of these veins is on the south and has not been explored, but is a well-defined vein at the points where the shaft and cross cuts have exposed it. The greenstone forms the hanging wall of the main vein, and is particularly regular and smooth, in some places beautifully polished. The foot wall consists in some parts of soft serpentine, and when the vein pinches it appears to be from swelling of the foot wall. No other mine in this region has such a structure as the Eureka, so far as I know, and there is very much in the peculiarities here described to favor the highest confidence in the permanence of this great ore channel, both in depth and extent.

It is interesting to analyze a little more in detail the returns of this mine, as illustrating a point already alluded to, viz—its progressive increase of gold with an increase of depth.

From October, 1865, to December 31, 1865, the quantity of quartz crushed was twenty-four hundred and forty-five tons, yielding an average of $33.87 per ton, and costing to mine and reduce $13.51.

From January 1st to June 1st, 1866, the crushing was forty-seven hundred and three tons, averaging $42.68 per ton, at a cost of $12.52 per ton.

From June 1st to September 30, 1866, the amount of quartz crushed was forty-two hundred twenty-seven and three-fourths tons, giving an average yield of $60.33 per ton, at a cost of $15.78 per ton.

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For the whole year ending September 30, 1866, the total crushing was eleven thousand three hundred and seventy-five and three-fourths tons, yielding a general average per ton of $47.15, at a mean cost per ton of $13.75.

The net profits for the year ending September 30, 1866, were $368,042.18. The ratio of costs of mining to the gross product was, for the three periods named above, respectively, 40½, 29½ and 26½ per centum. In the mining costs are included all charges for dead work, machinery, etc. The profits of the Eureka mine have, therefore, for the period named, averaged in round numbers from sixty to seventy-four per cent of the gross product of the mine. The earnings are divided every twenty-eight days, making thirteen annual dividends.

The bullion of the Eureka mine is about 850-thousandths fine, worth $17.57 per ounce. This value is, of course, slightly variable, say within five-thousandths.

ART. XXVIII.—*The Action of Sunlight on Glass;* by THOMAS GAFFIELD.

THE great attention now given to all the phenomena connected with light and heat may awaken some interest in the experiments in which I have been engaged for the past four years on the subject named at the head of this article. Perhaps I cannot better commence my essay, than by quoting from the "Proceedings of the Natural History Society," (vol. ix, p. 347) an account given before that Society, of my experiments in 1863, and after I had been engaged in them only a few months.

"He believed that his experiments in connection with the subject were original as to their method and their extent, although it had long been observed in Europe that colorless or light-colored plate-glass had turned to a purple hue by exposure to intense sunlight. One case* is cited of a change to a gold color; and one experiment recorded by Dr. Faraday,† some forty years ago, proving that a light purple changed to a darker hue after eight month's exposure.

"Other experiments are on record showing the action of glass of different colors as media in the transmission of light and of heat; but none, with the above exception, showing the effect produced on the glass itself.

"An experience of some twenty years in the window-glass business had only presented a few isolated cases of supposed change of color from this cause, which were attributed to some obvious defect in an article of inferior manufacture; but, within

* Journal of Society of Arts for Feb. 15, 1854.

† Dr. Faraday's Chemical Researches. London, 1859, p. 142.

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a short time, he had heard of the change of color in an article of superior manufacture, in a quantity of white plate glass, of which some lights had been broken out of a window in which they had been exposed to the sun.

"This fact coming to his knowledge led him to try an experiment with several specimens of plate, crown, and sheet glass, during the month of July last; which proved that a month's exposure to a hot sun would change the best white French plate and all-white sheet glass, such as is used for photographs and engravings, to a color containing more or less of a yellow hue. The dark green and dark blue or bluish green did not experience any change; but any hue which approached a white, whether bluish, greenish, or yellowish white, turned to a yellowish color.

A second series of experiments, commenced in July, and continued three months, on some thirty specimens from France, England, Belgium, Germany, and the United States, only confirmed the results of the first; and a daily examination at first, and afterward from week to week, and month to month, revealed the interesting fact, that, even after a single day's exposure to a July sun, the change of color will, in some instances of the lightest hues, commence.

"So remarkable was the change in a week, affecting nearly all the light-colored glasses, that he commenced a third experiment on the 6th of August which should speak for itself. He then exhibited to the Society ten pieces of French white plate-glass, four by two inches in size (all of which were cut from the same sheet), one of which showed the original colorless glass, and the others exhibiting the change of hue towards yellow, after exposure respectively of one, two, and four days; one, two, and three weeks; one, two, and three months.

"The changes in the first four days were slight; but the last specimens were so yellow as to exhibit a contrast very marked, and excited the interest of all the members present. That the color permeates the body of the glass, and is not confined to the surface, or produced by reflection therefrom, has been conclusively proved by grinding off about one-sixteenth of an inch from both surfaces and the four edges of a duplicate exposed specimen, which, after repolishing, still exhibited the same yellow color.

"The glasses exposed were all what are called colorless window-glasses, although they varied in tinge and hue from the whitest French plate to the darkest green English sheet-glass.

"An experiment for four months, from July to November, on really *colored* glasses, red, green, yellow, blue, and purple, showed no change except in the purple, which became slightly darker.

"The experiments were carried on upon a rough plate-glass roof, nearly horizontal, and which received the rays of the sun

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during the greater part of the day. In all cases, strips corresponding to those exposed, and cut off from the same pieces, were placed in the dark, to be compared with the other specimens after exposure.

"It will be noticed that the dark green, blue, and bluish green did not change. The color of the Belgian sheet (called German or French by glass-dealers in America), a yellowish or brownish green, did not change; and these were the only exceptions. All plate-glasses changed, except an inferior blue quality, and a superior crystal plate of a greenish color, made in Germany, and at the only factory which has not given up the use of potash for soda-ash.

"It is possible that a longer exposure of a year, or of years, might change every color in some degree.

"His inquiries, since he instituted these experiments, have brought out some fine specimens of Belgian sheet-glass from a house built three years ago, which had changed in some instances to a golden and in others to the well-known purple hue.

"It is his intention to pursue the experiments farther, with a view to ascertain the effects of sunlight during each month and season of the year; and also whether exposure to heat, air, or moisture alone, out of the direct action of the sun's rays, will produce any corresponding change.

"Mr. Gaffield does not propound any theory to explain these changes of color, which, under our sunny skies, probably take place much more rapidly than in the different and less clear atmosphere of England.

"Some writers point to the presence of oxyd of manganese in the original composition of window-glass, and some to the oxyd of iron, as a chief cause.

"Some writers have peculiar theories about the different classes of the sun's rays. Some may think the change referred to, a molecular or chemical one; and others, wiser than the rest, refrain from any explanation, waiting for a larger multiplication of experiments, and a greater accumulation of facts, before educing any satisfactory law of nature which governs these curious and interesting phenomena.

"Mr. G. makes no pretentions to any discoveries, unless it be to the very rapid change in glass observed in our climate in July, but only gives the result of his experiments, in the hope that the great interest now manifested in the subjects of light and heat may lead others to examine the matter, to repeat the same experiments in other countries, and to give the world the result of their researches, and enable the learned and scientific men of the age to explain this remarkable power and action of the sun's rays.

"It should be remembered that he submitted his specimens to

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the most severe tests by placing them where they received reflected as well as transmitted light and heat. The change in glass, when glazed in the windows of our dwellings and stores, is so much more gradual, that it very rarely attracts the attention of observers, except in the marked variation from white to purple."

In accordance with the intention above expressed, I have continued my experiments on this interesting subject, and under different heads will now give some account of their method and results.

My first experiment was with pieces of glass four by six inches, placed in a sash six by sixty inches long, in the grooves of which the specimens were placed, the sash being fastened together by wooden pins, and placed on a nearly horizontal rough plate-glass roof, which received the direct rays of the sun during the greater part of the day. In my next experiment, I placed some of the specimens directly on the rough plate-glass. These were carried on in summer and autumn. It was necessary to make a different arrangement for winter, when the fall of snow and the formation of ice might interfere with the full success of the experiments. I concluded that the best size for specimens was four by two inches, and I made some wooden boxes about $\frac{5}{8}$ inches deep, $4\frac{1}{4}$ inches wide, and of a length to fit the sills of windows facing the south, in the upper story of a Boston house. One of the windows was three-sided, looking east, south, and west. In these boxes, painted white, my specimens were placed in a nearly horizontal position, side by side, and, (after the loss of a few pieces, blown away by hurricanes and squalls), were secured in their positions by cords of twine or slight copper wire fastened at each end. I have arranged boxes on the roof in front of this window also, some being of greater depth in which to place pieces of plate and rough plate about one inch in thickness. All of these boxes are provided with covers, which are placed over the glass, and fastened by buttons, on the occurrence at any time of a snow storm. At all other times, the glass is exposed. Holes in proper places in the boxes allow the rain which falls to pass off easily. Every piece of glass is carefully marked by a diamond in an upper corner with its name, and if necessary, with some abbreviation descriptive of the experiment to which it belongs. This precaution is necessary to prevent mistakes, when a comparison is to be made of several kinds and colors, of exposed and unexposed specimens. In all cases, where an experiment is to be made with any description of glass, the pieces (4×2 inches in size) must all be cut from the same sheet, as there is frequently a slight difference in the shade of sheets from the

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same factory, arising from the difficulty of having the materials in their manufacture, and the circumstances attending the melting, blowing or casting precisely the same. Two pieces or more should be laid aside to show the original color, and to compare with the others, and thus to show the changes produced by exposure to sunlight for days, weeks, months or years. At the commencement of an experiment, say for instance, the exposure of white plate-glass for from one to twelve months, a neat paper box is provided, 4¼ inches long, 2⅛ inches deep and wide enough to hold fourteen pieces, (two of the original color, and twelve exposed specimens) and a description of the contents is marked on its cover on an adhesive label. At the end of each month, a piece is withdrawn from exposure, carefully cleaned, and marked either with a diamond or by an adhesive label, and placed in the box. As "order is heaven's first law," it is peculiarly necessary in all observations upon the actions of heaven's brightest luminary. By observing the above directions, much time will be saved, and at the conclusion of an experiment, everything is in shape for exhibition to friends at home, or students at a lecture room.

Of course a *perfect* arrangement could only be made when a perfectly flat roof or platform in an open field could be provided, and the sunlight could act with full force during every hour and minute of the day. But mine was sufficiently near this point to show very interesting results.

In one of my earliest experiments, I kept a record of the changes going on in the various kinds of glass, at first from day to day, and afterwards from week to week, and month to month. The following is a specimen:

Kinds of glass.	Original color before exposure.	Color after one day's exposure.	Here were inserted other columns to show effect of exposure for 2 and 4 days, for 1, 2 and 3 weeks, for 1 and 2 months.	Color at end of exp't. (3 mos.)
French white plate,				
English crown glass.				
French white sheet.				
Belgian sheet.				
American sheet. .				

I might give the names of all the different kinds of glass which I have exposed to sunlight, but I refrain because for the reason given previously, I have found different specimens from the same manufactory of plate, of crown, and of sheet-glass, sometimes to differ in shade, sometimes in result of exposure, and sometimes in both.

I will, however, give below, (not naming the particular manufactories), a general description of my experiments in 1863, when an exposure of thirty-three specimens for a few months in summer and autumn showed the following results.

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The first table shows that twenty-four kinds were found to be easily affected, and exhibits the time at which the change in color was first observed. The second table shows nine kinds which did not change in color during the same time.

Table of glasses easily changed.

Kinds of Glass.	Original color before exposure.
5 of French white plate.	White, with light bluish green tinge.
2 " German " "	White " " " " "
1 " English white plate.	White " " " " "
5 " " plate.	Yellowish green.
1 " Belgian rough plate.	White, with slight green tinge.
3 " French white sheet.	" with light bluish green tinge.
1 " Belgian " "	" " " yellowish green tinge.
4 " English " "	One light yellowish green and three light bluish green tinge.
2 " American " "	White, with light blue green tinge.
24	

The time at which change of color was first observed.									Color after exposure.
Days.			Weeks.			Months.			
1	2	4	1	2	3	1	2	3	
1		4							Yellow or yellowish green.
1				1					" "
1									" "
	4			1					Deeper yellow tinge.
		1							Yellowish green tinge.
3									" "
1									" "
	1		1	1		1			" "
1		1							" "
8	5	6	1	3		1			

Table of Glasses not changed in three months.

Kinds of glass.	Original color of glass.
1 kind of German crystal plate.	Light green.
1 " " " plate.	Dark blue.
1 " " English rough plate.	Dark green.
1 " " English crown.	Light green.
1 " " American "	Bluish green.
1 " " " sheet.	Dark bluish green.
1 " " English "	Dark green.
1 " " Belgian "	Yellowish or brownish green.
1 " " French "	" " " "
9	

Subsequent experiments with five of these kinds, (all which I could conveniently obtain), showed that an exposure of a year, or even less, would change all but an ordinary kind of American sheet, which was of a dark bluish green color.

The experiments which speak for themselves are the most satisfactory ones, that is to say, where one has not only the

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record made at the end of each month, but a piece of glass taken in and laid aside at the same time to show the actual color produced, and the truth of the records. It is very interesting to witness any one of these series of specimens, showing, as in one of white plate, a gradual change, commencing in a day or a few days in summer, from greenish or bluish white to a yellowish white, or light yellow, a deep and deeper yellow, until it becomes a dark yellow or a gold color; and in some Belgian sheet specimens, a gradual change, commencing in a few weeks in summer, from brownish yellow to deeper yellow, yellowish pink, pink, dark pink, purple and deep purple.

There are several kinds of glass in which no perceptible change took place in three months, which were very sensibly affected by an exposure of a year.

Experiments.—I have given a general account of my first experiments in 1863, and a portion of the tables kept in my journal at that time. I might have given names and results in full and shown the actual effects and shades of color produced by exposure for a few months, on some thirty kinds of glass. But in my case, as in many novel and original investigations, the results of first experiments, and the theories based upon them, were modified by subsequent ones. I supposed that many kinds of glass not changed in three months would not change at all: that all which changed would take a yellowish color, unless by exposure of many years: that no color but some shade of yellow or pink would ever be produced in any kind by exposure to sunlight.

The experiments of 1864 and the two following years, proved to me that nearly every kind of window glass I had exposed, could be changed in one year; that a rose or pink color, (or some tint approaching them) could be produced in various kinds in a few months; and that some kinds of greenish white glass would, after exposure, assume a bluish tint or bluish white.

It may seem singular for one who has been a glass dealer and manufacturer like ourselves, thus to advertise what may be called a defect in his own wares. It might seem unkind to other manufacturers to expose the defects of their productions, literally before the light of day. But my scruples have been all removed, when I have noticed in a late communication of Pelouze (see Comptes Rendus, Jan. 14, 1867) the following statement: "I do not believe that there exists in commerce a single species of glass that does not change its shade in the sunlight." As all manufacturers are in the same category, it will do no harm for me to repeat what Pelouze says, as the result of my experiments, and to affirm that a longer or shorter exposure to the direct action of the sun's rays will probably change in some degree the color of all or nearly all kinds of window glass.

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I subjoin an account of an experiment carried on for one year with nine different kinds of glasses. These represent plate, crown and cylinder glass, the manufactures of both hemispheres and almost every shade and color of what are called colorless glasses.

I name only the nationalities, and not the particular manufactories of the glasses in any of my tables. I have this information recorded in my journal, and shall be happy to communicate it to any who may desire it.

Memorandum of nine different kinds of glass exposed from Jan. 12, 1866, *to Jan.* 12, 1867.

Kind of glass.	Color before exposure.	Color after exposure.
French white plate.	Bluish white.	Yellowish color.
German crystal plate.	Light green.	Bluish tinge.
English plate.	" "	Yellowish green.
English crown.	" "	Light purplish color.
Belgian sheet.	Brownish yellow.	Deep " "
English sheet.	Dark green.	Brownish green.
American crystal sheet.	Light bluish white.	Purplish white.
" " "	Lighter bluish white.	Light yellowish green.
" ordinary "	Bluish green.	No change.

The colors named above are given from an observation of the glass edgewise, by which one can see a body of color two or four inches in depth, whereas the usual thickness of the glass varies from one-fourteenth to one-quarter of an inch, and shows its color easily only by placing a white curtain or paper behind it.

I have tried several experiments showing the effect of sunlight during each month and each season of the year. At the end of the year, by the comparative depth of yellow or purple color produced in the various specimens, one can see the comparative actinic power of the rays during each month and season. The results proved that the actinic effect increased from January to July, and decreased after that month. The greatest effect during any season was observed in the summer, the least in winter, and that in spring and autumn was about alike, and midway between that of summer and winter.

Crystal or lead glass, and a piece of optical glass having probably very little, if any, manganese, changed not in two years. Perhaps a longer exposure may produce some change.

A rough piece of light colored window glass metal changed to a yellowish color in a year.

Colored glasses after two or three years' exposure showed no perceptible change in any instance except a slight one in a single specimen of purple. Perhaps an exposure of many years may make a change in some other colors.

I have made experiments with artificial heat on glass in various ways, from exposure to the heat of a cooking range oven

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to that of a glass stainer's kiln, without any change of color in the common colorless window glasses, while the same or similar specimens exposed to sunlight have been nearly all changed in a few months.

Specimens exposed in hot water for a month, in doors and out of sunlight, experienced no change of color, while similar ones exposed during the same length of time in the bottom of a dish filled with two or three inches of water out of doors, and to the direct rays of the sun, experienced a decided change, though only about half as much as when directly exposed, out of the water.

Being convinced that air, moisture, and artificial heat do not make any change of color, our experiments indicate that the change is effected by the actinic rays of the sun alone.

This actinic effect is cut off in some degree by every medium, by water as stated above, and even by clear glass, as a specimen exposed inside of a window or under another piece of thin colorless glass shows only about one-half as much change, as that exposed outside of the window or with no covering of glass over it. The amount cut off by colorless glass and by colored glass differs greatly with the difference of color.

[To be concluded.]

ART. XXIX.—*Crystallogenic and Crystallographic Contributions;* by JAMES D. DANA.—No. IV. *On a connection between Crystalline form and Chemical constitution, with some inferences therefrom.—Supplement.*

I RETURN to the subject of my article published in the last number of this Journal in order to present a few additional remarks with regard to the bearings of the views on chemical science.

7. *Chemical formulas of the Silicates.*—In the attempts to write the formulas of the Silicates on the new system there has been a difficulty, as the results have shown, in arriving at similar formulas for related species. Part of the diversity in the formulas presented have arisen from the unsettled views among chemists themselves; but another part from the fact that the species vary widely through isomorphous substitutions, and especially through the occurrence, in the basic part, of the elements in different states of oxydation. The method of designating the elements as they exist in these several states by prefixing a Greek letter to the symbol, proposed in my former communication,* affords a convenient means of attaining all the uniformity and simplicity in the formulas that can be desired.

* This volume, page 89.

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It will be remembered that the states of R in the oxyds RO, R^2O^3, RO^2, RO^3, RO^5 (which are equivalent to RO, $3(R_{\frac{1}{3}}O)$, $2(R_{\frac{1}{2}}O)$, $3(R_{\frac{1}{3}}O)$, $5(R_{\frac{1}{5}}O)$), or in RS, R^2S^3, RS^2, etc., were made, respectively, the αR, βR, γR, δR, ϵR states, these symbols standing severally for R, $R_{\frac{2}{3}}$, $R_{\frac{1}{2}}$, $R_{\frac{1}{3}}$, $R_{\frac{1}{5}}$ in the above.

The larger part of the silicates are included in two divisions: the *Unisilicate*, and the *Bisilicate*,* as recognized in the edition of my Mineralogy of 1854. The Unisilicates have, on the old system, the general formula $\mathfrak{R}^2\mathfrak{S}i$, when only protoxyds are present, and $(\mathfrak{R}^3, \mathfrak{R})^2\mathfrak{S}i^3$, when part of the base is sesquioxyd, $\mathfrak{R}^3$ and $\mathfrak{R}$ being mutually replaceable in different proportions. The Bisilicates have the corresponding formulas $\mathfrak{R}\mathfrak{S}i$ and $(\mathfrak{R}^3, \mathfrak{R})\mathfrak{S}i^2$. With $\mathfrak{S}i$, the formulas are $\mathfrak{R}^3\mathfrak{S}i$, $(\mathfrak{R}^3, \mathfrak{R})\mathfrak{S}i$; and $\mathfrak{R}^3\mathfrak{S}i^2$, $(\mathfrak{R}^3, \mathfrak{R})\mathfrak{S}i^2$.

In writing these formulas on the new system, and adopting the system of symbols for the metal of the corresponding oxyds, αR, βR, etc. (but dropping the α as unnecessary), the formulas above cited become

for the ordinary Unisilicates (1) $\left.\begin{matrix}Si\\R_2\end{matrix}\right\}O_4$ (2) $\left.\begin{matrix}Si\\(R, \beta R)_2\end{matrix}\right\}O_4$

for the ordinary Bisilicates (1) $\left.\begin{matrix}SiO\\R\end{matrix}\right\}O_2$ (2) $\left.\begin{matrix}SiO\\(R, \beta R)\end{matrix}\right\}O_2$

The silicates of each division, whether containing sesquioxyds, or protoxyds, or both, have on this method essentially the same formulas. Moreover the other states of oxydation may be introduced with the same facility, and thus the remainder of the Unisilicates and Bisilicates be included. We thus bring under two expressions

Unisilicate, $\left.\begin{matrix}Si\\(R_2, R, \beta R, \gamma R, \delta R)_2\end{matrix}\right\}O_4$, Bisilicate, $\left.\begin{matrix}SiO\\(R_2, R, \beta R, \gamma R, \delta R)\end{matrix}\right\}O_2$

much the larger part of the silicates, and exhibit to the eye the fact of unity among them, and the truth also that in inorganic nature the types of compounds are few and of the simplest kind. By means of fractional coëfficients the atomic ratios between the R, βR, etc., are easily indicated.

By way of illustration I give below the special formulas of various mineral species under these general formulas, together with those also of the *Subsilicates*. The list is made longer than

* I use these terms in place of *Orthosilicates* and *Metasilicates*, because they express a definite fundamental fact under both the old and new systems of chemistry. In the *Unisilicates*, viewing them with reference to the new system, the two classes of elements combined with the oxygen, that is, the silicon, and R (or the basic metals), have between their *combining powers* the ratio 1 : 1; silicon, a *tetrad*, being associated with *two* basic *dyads*, or their equivalent; while in the *Bisilicates*, this ratio is 2 : 1, silicon being associated with *one* basic dyad or an equivalent. By employing the Latin numerals to express this relation as to combining powers, there is no conflicting with the numerals which are now in use, and which express the ratio between the elements themselves, the latter being all in Greek. Moreover the prefix *meta* in the term *metasilicate* has a diversity of significations in the new chemistry, while etymologically hardly any significancy whatever.

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would be necessary for a simple exemplification of the principle, in order to show the efficiency and wide application of the method proposed, and the close parallelisms which it exhibits in the formulas; and also because the subject of the formulas and true relations of the silicates is now attracting much attention.

The formulas beyond are written in a little different manner from what is usual, partly for the sake of compactness on the page, but more because I regard the position of the connecting O *between* the other two members of these ternaries as preferable to that ordinarily given, and better adapted to exhibit on the page the serial analogies and differences of the compounds.

If there are those who would prefer to see the ratios expressed in whole numbers instead of fractions, such can easily gratify themselves in this respect by performing the requisite multiplications. But when this work is done, the result is very far from complete; for in many species, as garnet, epidote, idocrase, pyroxene, hornblende, etc., R corresponds to a number of different elements, as Ca, Mg, Fe, Mn, and sometimes others; and βR to βFe, βAl, βCr, βMn; and several of these different metals may replace one another in the same specimen; and in different proportions in the same mineral from different localities; and the proportions appear to be at times indefinite. To clear away also these fractions arising from isomorphous substitutions would make formulas of great complexity, and in some cases almost as many different ones for a species as there may be localities if not analyses. And besides, the several formulas under a single species thus obtained would differ vastly in the number of atoms which they would indicate to be present in the different representatives of one and the same species, so that nature and chemical art would be put in direct variance.

There is no question that in most cases the formulas beyond should be taken in a multiple form in order to represent the true composition. Moreover, in examples of pleomorphism, such as garnet, allanite and biotite (epidote and idocrase may perhaps be included), the species probably differ by some simple ratio of multiples, as has been already explained. But until the exact multiple in any case has been ascertained, it appears to be best to retain the formula on the unit-scale here adopted. And even when ascertained, it may still be preferable to make the number expressing it a prefix to the whole formula here given, rather than to perform the multiplication with each member of it.

It may be objected to the following formulas that the βFe, βAl, γTi, &c., have only an ideal existence. But if in fact only ideal, they nevertheless belong *fundamentally* to the new system of chemistry. The metal in the sesquioxyds is capable of replacing *three* dyad elements, or *six* monads; and this the symbol recognizes. Moreover Fe^2 in Fe^2O^3 is a mere fiction, except as

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regards atomic weight; for Fe^2 is not Fe^2, or *two* of the dyad Fe, as it seems on the face of it to be. The fiction is avoided in the symbol adopted, and without implying any wrong idea with regard to the atomic weights.

Instead of using barred letters for the symbols of the elements whose atomic weights, in the new system, are double those of the old, I have employed small capitals for the remainder of them, that is, those of the perissads. The symbol of a perissad element is also indicated by the index $_2$ annexed to it; 2 of a monad replacing 1 dyad in these oxygen compounds. A list of the perissad elements will be found in the classification of the elements presented on a following page.*

I. Unisilicates.

A. *Anhydrous.*

Forsterite,	$Si\|O_4\|R_2$	$Si\|O_4\|Mg_2$
Fayalite,	"	$Si\|O_4\|Fe_2$
Tephroite,	"	$Si\|O_4\|Mn_2$
Chrysolite,	"	$Si\|O_4\|(Mg, Fe)_2$
Knebelite,	"	$Si\|O_4\|(Fe, Mn)_2$
Willemite,	"	$Si\|O_4\|Zn_2$
Phenacite,	"	$Si\|O_4\|Be_2$
Garnet,	$Si\|O_4\|(R, \beta R)_2$	$Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta R)_2$
Meionite,	"	$Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta R)_2$
Sarcolite,	"	$Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta R)_2$
Allanite,	"	$Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta R)_2$
Epidote,	"	$Si\|O_4\|(\frac{1}{3}R+\frac{2}{3}\beta R)_2$
Zoisite,	"	$Si\|O_4\|(\frac{1}{3}R+\frac{2}{3}\beta R)_2$
Piedmontite,	"	$Si\|O_4\|(\frac{1}{3}R+\frac{2}{3}\beta R)_2$
Mellilite,	"	$Si\|O_4\|(\frac{2}{3}R+\frac{1}{3}\beta R)_2$
Idocrase,	"	$Si\|O_4\|(\frac{2}{3}R+\frac{1}{3}\beta R)_2$
Zircon,	$Si\|O_4\|\gamma R_2$	$Si\|O_4\|\gamma Zr_2$
Biotite,	$Si\|O_4\|(\text{R}_2, R, \beta R)_2$	$Si\|O_4\|(\frac{1}{3}(\text{R}_2, R)+\frac{1}{3}\beta R)_2$
Phlogopite A,	"	$Si\|O_4\|(\frac{7}{11}(\text{R}_2, R)+\frac{4}{11}\beta R)_2$
" B,	"	$Si\|O_4\|(\frac{3}{4}(\text{R}_2, R)+\frac{1}{4}\beta R)_2$
Lepidomelane, A,	"	$Si\|O_4\|(\frac{1}{2}(\text{R}_2, R)+\frac{1}{2}\beta R)_2$
" B,†	"	$Si\|O_4\|(\frac{1}{3}(\text{R}_2, R)+\frac{2}{3}\beta R)_2$
Astrophyllite,‡	$Si\|O_4\|(\text{R}_2, R, \beta R, \gamma R)_2$	$Si\|O_4\|(\frac{9}{7}(\text{R}_2, R)+\frac{2}{7}\beta R+\frac{4}{7}\gamma(Ti, Zr))_2$
Axinite,	$Si\|O_4\|(R, \beta R, \delta\text{R}_2)_2$	$Si\|O_4\|(\frac{3}{7}R+\frac{4}{7}\beta R+\frac{1}{7}\delta\text{R}_2)_2$

* The author does not propose to substitute these new formulas for those of the old style in the forthcoming edition of his Mineralogy. They will appear only in tables by the side of the others.

† A is the original Lepidomelane as analyzed by Schlothelm, with which belongs also the Irish analyzed by Haughton. B is that of Rockport, Cape Ann, a brittle ferriferous mica intermediate in ratio between Lepidomelane and the magnesia mica, Biotite.

‡ From Pisani's analysis, C. R., lvi, 846.

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B. *Hydrous.*

Calamine,	$Si\|O_4\|R_2+naq$	$Si\|O_4\|Zn_2+\frac{3}{2}aq$
Cerite,	"	$Si\|O_4\|(Ce, La, Di)_2+aq$
Thorite,	"	$Si\|O_4\|Th_2+2aq$
Serpentine,*	$Si\|O_4\|(H_2, R)_2+naq$	$Si\|O_4\|(\frac{1}{4}H_2+\frac{3}{4}Mg)_2+aq$
Deweylite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}Mg)_2+\frac{4}{3}aq$
Hydrophite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(Mg, Fe))_2+\frac{4}{3}aq$
Genthite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(Mg, Ni))_2+\frac{4}{3}aq$
Ekmannite,†	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(Fe, Mn))_2+\frac{1}{3}aq$
Kaolinite,*	$Si\|O_4\|(H_2, \beta R)_2+naq$	$Si\|O_4\|(\frac{1}{4}H_2+\frac{3}{4}\beta Al)_2+aq$
Gillingite,	$Si\|O_4\|(R, \beta R)_2+naq$	$Si\|O_4\|(\frac{1}{3}R+\frac{2}{3}\beta Fe)_2+2aq$
Hisingerite,	$Si\|O_4\|(H_2, R, \beta R)_2+naq$	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(R, \beta Fe))_2+\frac{4}{3}aq$
Neotocite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(R, \beta Mn))_2+\frac{4}{3}aq$
Triclasite (Fahlunite),	"	$Si\|O_4\|(\frac{1}{2}H_2+\frac{1}{2}R+\frac{3}{2}\beta Al)_2$
Killinite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}(R, \beta Al))_2$
Prehnite,	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{2}{3}Ca+\frac{3}{3}\beta Al)_2$
Pinite,*	$Si\|O_4\|(H_2, K_2, R, \beta R)$	$Si\|O_4\|(\frac{1}{4}H_2+\frac{3}{4}(K_2, R, \beta Al))_2$
Margarodite,	"	$Si\|O_4\|(\frac{2}{3}H_2+\frac{1}{3}(K_2, R)+\frac{4}{3}\beta Al)_2$
Œllacherite,‡	"	$Si\|O_4\|(\frac{1}{3}H_2+\frac{1}{6}(K_2, R)+\frac{4}{3}\beta Al)_2$
Paragonite,	$Si\|O_4\|(H_2, K_2, \beta R)$	$Si\|O_4\|(\frac{2}{12}H_2+\frac{1}{12}Na_2+\frac{9}{12}\beta Al)_2$
Damourite,	"	$Si\|O_4\|(\frac{2}{12}H_2+\frac{1}{12}K_2+\frac{9}{12}\beta Al)_2$
Euphyllite,	$Si\|O_4\|(K_2, \beta R)+naq$	$Si\|O_4\|(\frac{1}{3}(K, Na)_2+\frac{2}{3}\beta Al)_2+\frac{1}{3}aq$

In several of the above species the water is all basic; in the others partly or wholly an accessory ingredient.

C. *With other accessory ingredients instead of water.*

Helvite,	$Si\|O_4\|R_2+$	$Si\|O_4\|(\frac{1}{3}(Mn, Fe)+\frac{1}{3}Be)_2+\frac{1}{3}MnS$
Danalite,	"	$Si\|O_4\|(\frac{1}{3}Mn, Fe, Zn)+\frac{1}{3}Be)_2+\frac{1}{3}ZnS$
Sodalite,	$Si\|O_4\|(K_2, \beta R)_2+$	$Si\|O_4\|(\frac{1}{4}Na_2+\frac{3}{4}\beta Al)_2+\frac{1}{3}Nacl$
Hauynite,	"	$Si\|O_4\|(\frac{1}{4}(K_2, R)+\frac{3}{4}\beta Al)_2+\frac{1}{3}S^a$
Nosite,	"	$Si\|O_4\|(\frac{1}{4}Na_2+\frac{3}{4}\beta Al)_2+\frac{1}{3}T^b$

[a] S=anhydrous sulphate of calcium. [b] T=anhydrous sulphate of sodium.

* Serpentine, Kaolinite and Pinite are closely related in formula. The oxygen ratio for the bases, silica and water, in the first two is 3 : 4 : 2, in the last, 3 : 4 : 1. Pinite is an alumina-alkali serpentine, and Kaolinite (Pholerite, in part) an alumina serpentine, as pyrophyllite is an alumina talc.

Pinite includes many pseudomorphous potash silicates; as Liebnerite, Gieseckite, Dysyntribite, Pinitoid, Wilsonite, Lythrodes, Fellenberg's green mineral resembling compact green talc from the moraine of the Grindelwald glacier; and Gigantolite, Iberite, Polyargite, Rosellan appear to be impure conditions of the species.

† B. H. Ztg., xxvi, 21, 1867.

‡ Œllacher's margarite from Pfitschthal, Kenngott's Uebers., 1860, 49. The author has learned from Dr. Krantz that the margarite analyzed by Prof. G. J. Brush, to whom he furnished the specimen, is the original margarite, and that therefore Œllacher's is not so. Dr. Krantz in a note dated Bonn, March 17, 1867, says: "The specimen of margarite Prof. Brush obtained from me came from the Greiner mount in Tyrol. It occurs there in irregular masses in the mica slate in several varieties, passing from a pearl-white color into green and gray; it was formerly a very common mineral, but has of late become scarce. This was the only known locality in Tyrol, till Œllacher analyzed a mica of similar appearance, occurring with Rhætizite very near Kemmat in the Pfitsch valley in Tyrol, containing barytes, to which also he gave the name margarite. The two localities are about two and a half German or twelve English miles in a direct line from one another."

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The species here included are all of the isometric system, the system which is peculiarly defiant of change from isomorphous substitutions; and they are alike of the *garnet* group.

II. Bisilicates.

A. *Anhydrous.*

Wollastonite,	$SiO\|O_2\|R$	$SiO\|O_2\|Ca$
Enstatite,	"	$SiO\|O_2\|Mg$
Kupfferite,	"	$SiO\|O_2\|Mg$
Grünerite,	"	$SiO\|O_2\|Fe$
Rhodonite,	"	$SiO\|O_2\|Mn$
Pyroxene,	"	$SiO\|O_2\|(Ca, Mg, Fe, Mn)$
Hypersthene,	"	$SiO\|O_2\|(Mg, Fe)$
Anthophyllite,	"	$SiO\|O_2\|(\frac{3}{4}Mg+\frac{1}{4}Fe)$
Amphibole, A,	"	$SiO\|O_2\|(Mg, Ca, Fe, Mn)$
" B,	"	$SiO\|O_2\|(H_2, Mg, Ca, Fe, Mn)$*
Babingtonite,	$SiO\|O_2\|(R, \beta R)$	$SiO\|O_2\|(\frac{4}{5}(Fe, Mn)+\frac{1}{5}\beta Fe)$
Beryl,	"	$SiO\|O_2\|(\frac{1}{3}Be+\frac{1}{3}\beta Al)$
Ægirine,	$SiO\|O_2\|(R_2, R, \beta R)$	$SiO\|O_2\|(\frac{1}{3}(Na_2, R)+\frac{1}{3}\beta Fe)$
Wichtisite,	"	$SiO\|O_2\|(\frac{1}{3}(Na_2, R)+\frac{1}{3}\beta Al)$
Acmite,	"	$SiO\|O_2\|(\frac{1}{3}(Na_2, R)+\frac{2}{3}\beta Fe)$
Arfvedsonite,	"	$SiO\|O_2\|(\frac{2}{3}(Na_2, R)+\frac{3}{3}\beta Fe)$
Spodumene,	$SiO\|O_2\|(R_2, \beta R)$	$SiO\|O_2\|(\ (Li_2, Na_2)+\frac{4}{3}\beta Al)$
Cryophyllite,	"	$SiO\|O_2\|(\frac{3}{4}(K_2, Li_2, R)+\frac{1}{4}\beta Al)$
Eudialyte,	$SiO\|O_2\|(R_2, R, \gamma R)$	$SiO\|O_2\|(\frac{3}{4}(Na_2, R)+\frac{1}{4}\gamma Zr)$†

B. *Hydrous.*

Talc, A,	$SiO\|O_2\|(H_2, R)$	$SiO\|O_2\|(\frac{1}{3}H_2+\frac{2}{3}Mg)$
" B,	$SiO\|O_2\|(H_2, R)+naq$	$SiO\|O_2\|(\frac{1}{3}H_2+\frac{2}{3}Mg)+\frac{1}{15}aq$
Sepiolite (Meerschaum),	"	$SiO\|O_2\|(\frac{1}{2}H_2+\frac{1}{2}Mg)+\frac{1}{2}aq$
Pyrophyllite,	$SiO\|O_2\|(H_2, \beta R)+naq$	$SiO\|O_2\|(\frac{1}{3}H_2+\frac{2}{3}\beta Al)+\frac{1}{15}aq$
Cimolite,	"	$SiO\|O_2\|(\frac{1}{2}H_2+\frac{1}{2}\beta Al)+\frac{1}{2}aq$
Okenite,	$SiO\|O_2\|(H_2, R)+naq$	$SiO\|O_2\|(\frac{1}{2}H_2+\frac{1}{2}Ca)+\frac{1}{2}aq$
Laumontite,	$SiO\|O_2\|(R, \beta R)+naq$	$SiO\|O_2\|(\frac{1}{2}Ca+\frac{1}{2}\beta Al)+aq$
Pectolite,	$SiO\|O_2\|(H_2, R_2, R)$	$SiO\|O_2\|(\frac{1}{6}H_2+\frac{5}{6}(Na_2, Ca))$
Dioptase,	$SiO\|O_2\|R+naq$	$SiO\|O_2\|Cu+aq$

III. Subsilicates.

In the Subsilicates, the combining power of the silicon is less than that of the basic metal, the oxygen ratios for the bases and silicon being 3 : 2, 2 : 1, and 4 : 3, of which 3 : 2 is the most common. The only silicates of aluminum (or of an element in the beta state) known among minerals are Subsilicates; all the Uni-

* Much amphibole contains some water; and according to Lechartier 1 to 1·5 p. c. exist in ordinary tremolite and other varieties, and this water requires a red heat to expel it. Making the water basic the ratio becomes 2 : 1 when not so without.

† Rammelsberg's analysis makes the oxygen ratio for $\dot{R}, \dddot{R}, \ddot{Si}$=8·93 : 4·44 : 26·62 =2 : 1 : 6.

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silicates and Bisilicates containing aluminum contain also one or more basic metals in the *protoxyd* state.

The formulas of the mineral species here included are as follows, if the oxygen be not divided—the only method according to which they have been written in recent works on chemistry.*

A. *Anhydrous.*

	Ratio.		
Chondrodite,	4 : 3	$R_6\|(O, F)_{14}\|Si_3$	$Mg_6\|(O, F)_{14}\|Si_3$
Tourmaline,	4 : 3	$(R_2, R, \beta R, \delta R_2)_3\|(O, F)_{14}\|Si_3$	$(R_2, R, \beta Al\ \delta R_2)_6\|(O, F)_{14}\|Si_3$
Andalusite,	3 : 2	$\beta R_3\|O_5\|Si$	$\beta Al_3\|O_5\|Si$
Sillimanite,	3 : 2	"	$\beta Al_3\|O_5\|Si$
Kyanite,	3 : 2	"	$\beta Al_3\|O_5\|Si$
Gehlenite,	3 : 2	$(R, \beta R)_3\|O_5\|Si$	$(\frac{1}{2}R+\frac{1}{2}\beta R)_3\|O_5\|Si$
Sphene,	3 : 2	$(R, \gamma R)_3\|O_5\|Si$	$(\frac{1}{2}Ca+\frac{1}{2}\gamma Ti)_3\|O_5\|Si$
Tscheffkinite,	3 : 2	"	$(\frac{4}{5}R+\frac{1}{5}\gamma Ti)_3\|O_5\|Si$
Grothite,†	3 : 2	$(R, \beta R, \gamma R)_3\|O_5\|Si$	$(\frac{4}{5}Ca+\frac{1}{5}\beta Fe+\frac{1}{5}\gamma Ti)_3\|O_5\|Si$
Keilhauite,	3 : 2	"	$(\frac{6}{15}R+\frac{3}{15}\beta R+\frac{7}{15}\gamma Ti)_3\|O_5\|Si$
Topaz,	3 : 2	$\beta R_3\|(O, F)_5\|Si$	$\beta Al_3\|(\frac{1}{2}O+\frac{1}{2}F)_5\|Si$
Staurolite,‡	2 : 1	$(H_2, R, \beta R)_4\|O_6\|Si$	$(\frac{1}{4}(H_2, R)+\frac{3}{4}\beta R)_4\|O_6\|Si$
Schorlomite,	2 : 1	$(R, \beta R, \gamma R)_4\|O_6\|Si$	$(\frac{4}{11}R+\frac{3}{11}\beta R+\frac{4}{11}\gamma R)_4\|O_6\|Si$

B. *Hydrous.*

	Ratio.		
Pyrosclerite,	4 : 3	$(H_2, R, \beta R)_5\|O_{14}\|Si_3+naq$	$(\frac{1}{2}H_2+\frac{3}{2}R+\frac{1}{2}\beta R)_5\|O_{14}\|Si_3+2aq$§
Pennine,	"	$(R, \beta R)_5\|O_{14}\|Si_3+naq$	$(\frac{3}{5}R+\frac{1}{5}\beta R)_5\|O_{14}\|Si_3+4aq$‖
Ripidolite,	"	"	$(\frac{4}{5}R+\frac{1}{5}\beta R)_5\|O_{14}\|Si_3+4aq$‖
Cookeite,	"	$(H_2, R_2, \beta R)_5\|O_{14}\|Si_3+naq$	$(\frac{1}{12}H_2+\frac{1}{12}(Li, K)_2+\frac{10}{12}\beta Al)_5\|O_{14}\|Si_3+3aq$

* The principles of the new system seem to suggest for the rational formula one of the two following methods; which of the two, I leave for others to decide.

	Ratio 3 : 2.	Ratio 2 : 1.	Ratio 4 : 3.
I.	$(R, \beta R)O\|O_4\|Si$	$(R, \beta R)O_2\|O_4\|Si$	$(R, \beta R)O_3\|O_{12}\|Si_3$
II.	$(R, \beta R)O_2\|O_3\|SiO$	$(R, \beta R)O_2\|O_3\|SiO$	$(R, \beta R)O_2\|O_3\|Si_2O_3$

† Described as a variety of Titanite by Groth in the Jahrb. Min., 1866, p. 44.

‡ Lechartier has found (Bull. Soc. Ch., II, iii, 378, 1865) that the variations in the silica, etc., observed in staurolite by Rammelsberg are due to impurities, and that after separating the impurities, the amount of silica is uniformly 28·1 to 29·2 p. c.; and further, that 1·3 to 1·5 p. c. of water were present in the pure staurolite, which required near red heat to expel it.

§ From von Kobell's analysis. The ratio is 1 : 1 if the water be excluded; but 4 : 3 as in Pennine, if half the water be made basic. As in the case of the silicate group generally, and many other hydrous silicates, the true constitution must remain in doubt until the state of the water has been definitively determined.

‖ Pennine affords in part the ratio 5 : 4, but 4 : 3 is probably the true ratio. Optically Pennine is hexagonal, and *Ripidolite* (Clinochlore) monoclinic. Von Kobell's name, Ripidolite, has priority; and, moreover, a second kind of Clinochlore or monoclinic Chlorite exists; the *Corundophilite* of Chester, Mass., having been found to have the optical bisectrix oblique to the plane of cleavage by Descloizeaux, and later by Prof. J. P. Cooke (this vol., p. 206). There are hence *two hexagonal* and *two monoclinic* chlorites. The Corundophilite approaches more nearly the hexagonal chlorite in composition than Ripidolite (Clinochlore); the formula for it is from Pisani's analysis, whose specimens were optically examined by Descloizeaux.

Since *Chlorite* has become the name of a group of species, the hexagonal chlorite requires another name; and it is accordingly designated above *Prochlorite*, it being the *first* crystallized chlorite recognized by Werner.

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Euclase,	3 : 2	$(H_2, R, \beta R)_3 \vert O_6 \vert Si$	$(\frac{1}{3}H_2+\frac{2}{3}Be+\frac{2}{3}\beta Al)_3 \vert O_6 \vert Si$
Datolite,	"	$(H_2, R, \delta_R)_3 \vert O_6 \vert Si$	$(\frac{1}{3}H_2+\frac{2}{3}Ca+\frac{2}{3}\delta_B)_3 \vert O_6 \vert Si$
Prochlorite,	"	$(R, \beta R)_3 \vert O_6 \vert Si+naq$	$(\frac{4}{3}R+\frac{2}{3}\beta Al)_3 \vert O_6 \vert Si+1\frac{1}{3}aq$*
Cronstedtite,	"	"	$(\frac{1}{3}R+\frac{1}{3}\beta Fe)_3 \vert O_6 \vert Si+1\frac{1}{3}aq$
Corundophilite,	2 : 1	$(R, \beta R)_4 \vert O_6 \vert Si+naq$	$(\frac{1}{4}R+\frac{1}{4}\beta R)_4 \vert O_6 \vert Si+1\frac{3}{4}aq$*
Chloritoid,	"	"	$(\frac{1}{2}R+\frac{1}{2}\beta R)_4 \vert O_6 \vert Si+aq$
Margarite,	"	$(H_2, R, \beta R)_4 \vert O_6 \vert Si$	$(\frac{1}{3}H_2+\frac{1}{3}R+\frac{2}{3}\beta R)_4 \vert O_6 \vert Si$
Thuringite,	"	"	$(\frac{1}{3}H_2+\frac{2}{3}R+\frac{2}{3}\beta R)_4 \vert O_6 \vert Si$
Seybertite,	3 : 1	$(R, \beta R)_6 \vert O_6 \vert Si+naq$	$(\frac{2}{3}R+\frac{2}{3}\beta R)_6 \vert O_6 \vert Si+\frac{1}{3}aq$†
Xanthophyllite,	4 : 1	$(R, \beta R)_8 \vert O_{10} \vert Si+naq$	$(\frac{4}{3}R+\frac{4}{3}\beta R)_8 \vert O_{10} \vert Si+aq$‡

The species Ilvaite, from Elba, appears from the analyses to fall among Subsilicates. But the oxygen ratio between the basic metals and the silicon varies in the analyses from 5 : 4 to 9 : 8; and in the mineral from Nassau, regarded as the same species (Tobler, Journ. Ch. Pharm., xcix, 122), the ratio is 1 : 1. Städeler states that 1 to 2 p. c. of water is always present which is expelled only by the heat of ignition; and making the water basic, arrives at the ratio 5 : 4 for the species. Another view, perhaps quite as probable, considering the opacity of the species and Lechartier's results with staurotide, is that the mineral of Elba contains some $\dot{F}e\dot{H}$ (Göthite) as impurity; and that this causes the divergence from the ratio 1 : 1.

IV. Intermediate Silicates.

The silicates in which the oxygen ratio for the basic metals and silicon is between 1 : 1 and 1 : 2 have been called *Parasilicates* by Odling, being regarded as combinations of a Unisilicate and Bisilicate. The ratio

1 : $1\frac{1}{2}$,	occurs in	Leucophane and Lepidolite,	and would	correspond to	1U + 2B
1 : $1\frac{1}{4}$	"	Muscovite and Iolite,	"	"	$1\frac{1}{2}$U + 1B
1 : $1\frac{1}{3}$	"	Nepheline,	"	"	$3\frac{1}{2}$U + 1B

The discovery by Prof. J. P. Cooke of a bisilicate mica, cryophyllite, has led this chemist to sustain the view that the micas are isomorphous combinations of the above kind, the group now including three or more Unisilicates, one Bisilicate, and the two intermediate species, lepidolite and muscovite.

Besides the above species of intermediate silicates there are the various compounds grouped under the species Wernerite (Scapolite) together with the related Meionite and Mizzonite. The minerals here alluded to have the same crystallization and belong to one group, and, according to Rose, and others to one species, Meionite. The divergence from the unisilicate ratio has

* See note (‖) on preceding page.

† From the analyses by Brush, who obtained but 1·50 p. c. of water, more than half less than other analysts had found.

‡ From Meitzendorf's analyses.

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been attributed to alteration, and to impurities; and also by others to a variation in chemical ratio analogous to that among the feldspars. I pass the subject without discussion.

The species of Silicates which remain are the Feldspars and the Zeolites. The Feldspars may be regarded as *unisilicate* in anorthite; *bisilicate* in andesine and leucite; *tersilicate* in albite and orthoclase; $1\frac{1}{2}$-*silicate* in labradorite; $2\frac{1}{4}$-*silicate* in oligoclase. But this view would disband one of the most natural groups of silicates, and introduce the only example of a *tersilicate* among anhydrous silicates. I have seen no satisfactory explanation of the unity of the group, and am not prepared to offer one. The theory of the Zeolites seems to be one with that of the Feldspars.*

* Tschermak has proposed a method of deducing a common formula for the Feldspars which has had some favor, and may have here a passing remark. At the extremes in the series of feldspars are *Anorthite* and *Albite*, the former containing calcium, aluminum and silicon, with the oxygen ratio 1 : 3 : 4; and the latter sodium, aluminum and silicon, with the ratio 1 : 3 : 12. Tschermak brings these extremes under one formula as follows. By making the number of atoms of oxygen in the two the same (which is done by doubling the Anorthite), the sum of the number of equivalents of aluminum and silicon (taking silica as SiO^2) in the two is the same; and also, if we write Na_2 for Na, in accordance with the new chemistry, the number of atoms of protoxyds is the same. Then, assuming that the Al and Si are replaceable 1 for 1, and K, Ca, 1 for 1, the formulas become, for

$$\text{Albite,} \quad Na^2\ Al^2\ Si^2\ Si^4\ O^{16}$$
$$\text{Anorthite,} \quad Ca^2\ Al^2\ Al^2\ Si^4\ O^{16}$$

and are parallel throughout. The result *looks* well. But this substitution, atom for atom, of a tetrad (Si) and a pseudotriad (Al), and also of a monad (Na) and a dyad (Ca), is an impossibility. It takes two of a monad to replace a dyad.

If silicon may be basic and replace aluminum it is a much simpler method of arriving at like formulas for the species (and one correct in the ratio in which Si and Al may replace one another) to make a direct transfer as follows: The first column contains the oxygen ratios, as ordinarily given; the second, the same with part of the silica transferred to the bases and added to the alumina; the third, the resulting general ratio for the bases and silica.

	Oxygen ratio.	Oxygen ratio.	Oxygen ratio.
	$\dot{R}\ \dddot{R}\ \dddot{Si}$	$\dot{R}\ \dddot{Al}+\dddot{Si}\ \dddot{Si}$	Bases : Silica.
Anorthite,	1 : 3 : 4	1 : 3 + 0 : 4	1 : 1
Labradorite,	1 : 3 : 6	1 : 3 + 1 : 5	1 : 1
Andesite,	1 : 3 : 8	1 : 3 + 2 : 6	1 : 1
Oligoclase,	1 : 3 : 9	1 : 3 + $2\frac{1}{2}$: $6\frac{1}{2}$	1 : 1
Albite, Orthoclase,	1 : 3 : 12	1 : 3 + 4 : 8	1 : 1

The species are thus all reduced to *Unisilicates*, of the Anorthite and Garnet type, with the general formula

$$Si\|O_4\|(R_2, R, \beta Al, \gamma Si)_2;$$

and, accordingly, the following would be the special formulas of Anorthite, Labradorite and Albite:

$$\text{Anorthite,} \quad Si\|O_4\|(\tfrac{1}{4}R+\tfrac{3}{4}\beta Al)_2$$
$$\text{Labradorite,} \quad Si\|O_4\|(\tfrac{1}{5}(Na_2, Ca)+\tfrac{3}{5}\beta Al+\tfrac{1}{5}\gamma Si)_2$$
$$\text{Albite,} \quad Si\|O_4\|(\tfrac{1}{8}Na_2+\tfrac{3}{8}\beta Al+\tfrac{4}{8}\gamma Si)_2$$

Formulas for the others may be written in the same manner.

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8. *Classification of the Elements.*—On page 94 of my former paper, it was stated, among the inferences from the principles discussed, that the metals in their different states, as indicated by their different grades of combinations, that is, $^{\alpha}R$, $^{\beta}R$, $^{\gamma}R$, $^{\delta}R$, $^{\epsilon}R$, should be arranged in different groups in a classification of the elements. This principle has been, in part, for some time admitted. The following scheme of classification, thus made out, in brief, is here introduced as a supplement to the preceding tables of formulas, to make more manifest the general relations of the elements in their different states, and to present to view the author's reasons for regarding zirconium in zircon, eudialyte, astrophyllite, etc.; titanium in sphene, keilhauite, astrophyllite, etc.; boron in axinite, datolite, tourmaline, *basic* metals, and the compounds with silicon silicates, while at the same time the near relation between these metals and silicon is fully admitted.

Classification of the Elements.

Series I.	**Series II.**	**Series III.**
A. *Perissads* (Monads).	A. *Perissads.*	A. *Perissads* (Monads).
Potassium, Sodium, Cæsium, Rubidium, Lithium, Thallium, Hydrogen, Silver, Gold.	Nitrogen, Phosphorus, Arsenic, Antimony, Bismuth, Columbium, Tantalum. Boron.	Chlorine, Bromine, Iodine.
B. *Artiads.*	B. *Artiads.*	B. *Artiads.*
1. Iron-Aluminum Group.	1. Sulphur Group.	
a. Iron Sub-group. — Platinum, etc., Copper, Lead, etc., Iron, Cobalt, Zinc, Cadmium, Nickel, Manganese, Chromium, Tungsten, etc., Cerium, Yttrium, etc., Magnesium, Calcium, Strontium, Barium; also H_2, K_2, Na_2, etc.		*a.* Fluorine.
b. Aluminum Sub-group.—Aluminum (βAl); also βFe, βMn, βCr, etc.	Sulphur (δS), Selenium, Tellurium, Molybdenum; also δFe, δCr, δMn, δV, δW, δAs_2, δB_2.	*b.* Oxygen.
2. Tin Group.	2. Carbon-Silicon Group.	
Tin, Titanium, Zirconium, Thorium; also γH, γFe, γMn, γCo, γPb, γCu, etc.	Carbon, Silicon; also γS, γSe, γTe, etc.	

It is observed that in this classification *three* series of elements are recognized, which are designated by numbers, Series I, II, III. They might be called the *basic, medial*, and *acidic* series; or the *basic, subacidic*, and *peracidic*. But it seems as well to call them simply by their numbers, since, owing to the diversities

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among the species of each series, the above descriptive names are only in a general way, and not specifically, applicable.

The classification is, in our view, a natural one, whether read vertically or transversely.

Looking at it vertically, the three series correspond severally with the three grades of elements in the oxygen ternary compounds or salts, the acidic element being of Series III; the second element in order, silicon, of Series II; and the basic metals of Series I. The elements of Series I are eminently the basic elements. Among those of Series II arsenic and others of the first group often replace isomorphically sulphur of the second group; and RO^2 of the sulphur group makes salts that are isomorphous with those of CO^2. The near relations of the species of Series III have always been recognized.

Viewing the arrangement horizontally, the three Divisions A, at the top of the series, include the Perissads, or those elements the ratios of whose combinations are by *odd* numbers, as 1 : 1, 1 : 3, 2 : 3, etc.; while the three Divisions B, across, include the Artiads, or those whose combinations are by *even* numbers, as 2 : 2 (in the Iron Sub-group), 4 : 6 (in the Aluminum Sub-group), 2 : 4 (in the Tin Group and Carbon-Silicon Group), 2 : 6 (in the Sulphur Group). The recognition of this distinction of odd and even is universally regarded as one of the most important deductions of modern chemical science.

Again, opposite the Iron-Aluminum Group in Series I, stands the Sulphur group in Series II; and many metals which are represented in the Iron-Aluminum Group are also represented in the Sulphur Group. Again, Oxygen, of Series III, stands opposite Sulphur of Series II, whose relations to oxygen are fundamental.

Again, the Tin Group in Series I is in the same horizontal division with the Carbon-Silicon Group in Series II. The mutual relations of the two are thus recognized; and, also, by the arrangement in distinct series, the actual diversity as to their grade in ternaries. For silicon stands on a virtually higher level than tin and titanium, and throws the latter into the inferior basic relation whenever they occur together. As Ti joins with Fe to form with oxygen a sesquioxyd, closely isomorphous with hematite (Fe^2O^3) and also physically like it, so Ti may join with Ca (as in Perofskite) or with any other metal of that sub-group, in a sesquioxyd; and so also it may be basic in any combination with silica, as in sphene, etc., page 258. Accordingly, also, SiO^2 and ZrO^2 make together, not a mere combination of two coördinate isomorphs, but a true Unisilicate, as recognized in the formula on page 255. The formulas of the silicates which have been given and the classification we regard as mutually illustrating and sustaining one another.

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Fluorine is placed among the Artiads, because of its frequent replacement of oxygen, the analogies of its ternaries with those of oxygen, and the nature of some other of its compounds, although it acts in many cases as a Perissad. But with regard to it no special relation in a horizontal view of the classification is intended to be indicated.*

Art. XXX.—*Formic versus Carbonous acid;* by George F. Barker.

In studying the primary oxyds of the negative simple radicals, (the acids) for the purpose of classification, it is evident that the equivalence of the radical varies in each of the acids which it forms. In sulphuric acid, sulphur is a hexad, while in sulphurous acid it is a tetrad and in hyposulphurous acid a dyad. Conversely we may expect to find as many acids as the radical by such changes in its equivalence, can produce. Phosphoric acid contains phosphorus as a pentad; but since this radical may act as a triad, phosphorous acid is thus predicted. In the case of the tetrad carbon we have carbonic acid; but since carbon may act as a dyad, carbonous acid is also possible. I propose to give here some of the arguments which may be adduced to show that formic acid is the acid in question.

1. The formula of formic acid, usually written $\left.\begin{matrix}(\text{CH}\Theta)\\ \text{H}\end{matrix}\right\}\Theta$, may equally well be written $\left.\begin{matrix}\text{C}''\\ \text{H}_2\end{matrix}\right\}\Theta_2$, both being equal to $\text{H}_2\text{C}\Theta_2$, corresponding to carbonic acid $\text{H}_2\text{C}\Theta_3$. Potassic formate $\left.\begin{matrix}(\text{CH}\Theta)\\ \text{K}\end{matrix}\right\}\Theta$ equals $\left.\begin{matrix}\text{C}\\ \text{HK}\end{matrix}\right\}\Theta_2$, and the ethers $\left.\begin{matrix}(\text{CH}\Theta)\\ (\text{C}_n\text{H}_{2n+1})\end{matrix}\right\}\Theta$ may be $\left.\begin{matrix}\text{C}\\ \text{H}(\text{C}_n\text{H}_{2n+1})\end{matrix}\right\}\Theta_2$.

2. Hofmann's formamid $\left.\begin{matrix}(\text{CH}\Theta)\\ \text{H}\\ \text{H}\end{matrix}\right\}\text{N}$ may be viewed as $\left.\begin{matrix}(\text{C}'')\text{H}_2\text{N}\\ \text{H}\end{matrix}\right\}\Theta$ carbimic acid, corresponding to carbamic acid $\left.\begin{matrix}(\text{C}\Theta)\text{H}_2\text{N}\\ \text{H}\end{matrix}\right\}\Theta$. Especially since ethyl-formamid $\left.\begin{matrix}(\text{CH}\Theta)\\ \text{C}_2\text{H}_5\\ \text{H}\end{matrix}\right\}\text{N}$ may be ethylic carbimate $\left.\begin{matrix}(\text{C}'')\text{H}_2\text{N}\\ \text{C}_2\text{H}_5\end{matrix}\right\}\Theta$.

* Near the last of June, Prof. G. Hinrichs, of Iowa University, published in German a memoir on *Atom Mechanics*, which, while the views are widely different, has some points of agreement with my paper in the July number of this Journal. A copy of the memoir reached this place July 2d, after my paper was printed, but nearly three weeks before the July number was issued. I had intended to have an abstract of it in this number, but am unable to accomplish it, and therefore defer it to our next.

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3. The radical formyl (CHO), unlike acetyl ($\text{C}_2\text{H}_3\text{O}$), is not required to formulate the derivatives of the acid. Moreover, no chlorid or hydrid of this radical exists. The anhydrous acid (formylic oxyd), too, $\left.\begin{matrix}\text{C}\text{H}\text{O}\\\text{C}\text{H}\text{O}\end{matrix}\right\}\text{O}$ is unknown. If, however, the acid be $\left.\begin{matrix}\text{C}\\\text{H}_2\end{matrix}\right\}\text{O}_2$, then its secondary oxyd would be $\text{C}''\}\text{O}$, carbonic oxyd.

4. Its synthesis. We have—*a*, Berthelot's method,

$$\text{HK}\text{O}+\text{C}\text{O}=\text{HK}\text{C}\text{O}_2\text{; just as HK}\text{O}+\text{S}\text{O}_2=\text{HKS}\text{O}_3.$$

b, Kolbe's method by deoxydizing $\text{H}_2\text{C}\text{O}_3$,

$$(\text{H}_2\text{C}\text{O}_3)_2+\text{Na}_2=\text{HNa}\text{C}\text{O}_2+\text{HNa}\text{C}\text{O}_3+\text{H}_2\text{O}.$$

c, Dupré's method, $\text{H}_2\text{C}\text{O}_3+\text{C}+\text{H}_2\text{O}=(\text{H}_2\text{C}\text{O}_2)_2$; similar to $\text{H}_2\text{S}\text{O}_3+\text{S}+\text{H}_2\text{O}=(\text{H}_2\text{S}\text{O}_2)_2$.

d, Chapman's method, partial oxydation of carbon,

$$\text{C}+\text{O}+\text{H}_2\text{O}=\text{H}_2\text{C}\text{O}_2.$$

5. Its preparation. *a*, from oxalic acid $\text{H}_2\text{C}_2\text{O}_4=\text{H}_2\text{C}\text{O}_2+\text{C}\text{O}_2$, as well as the reverse action; *b*, from cyanhydric acid

$$\left.\begin{matrix}\text{C}''\\\text{H}\end{matrix}\right\}\text{N}+\left.\begin{matrix}\text{H}_2\\\text{HK}\end{matrix}\right\}\text{O}_2=\left.\begin{matrix}\text{C}''\\\text{HK}\end{matrix}\right\}\text{O}_2+\left.\begin{matrix}\text{H}_2\\\text{H}\end{matrix}\right\}\text{N}.$$

And in general its production from the oxydation of carbonaceous materials. In no case is the intermediate body formic aldehyd, obtained; this anomalous result is accounted for if the acid be $\left.\begin{matrix}\text{C}''\\\text{H}_2\end{matrix}\right\}\text{O}_2$.

6. Its decompositions. Like sulphurous and similar acids, it readily reduces metallic salts; it is oxydized readily by platinum black; by action of $\text{H}_2\text{S}\text{O}_4$, $\text{H}_2\text{C}\text{O}_2$ gives H_2O and CO, the anhydrid; the action of PCl_5 produces no formylic chlorid, $\text{H}_2\text{C}\text{O}_2+\text{PCl}_5=\text{PCl}_3\text{O}+\text{C}\text{O}+(\text{HCl})_2$; chlorine gives $\text{H}_2\text{C}\text{O}_2+\text{Cl}_2=\text{C}\text{O}_2+(\text{HCl})_2$.

7. Its acknowledged divergence from the acetic or fatty acid series, in which it is usually classed. These acids resist the oxydizing action of dilute chromic acid, while formic acid on the other hand is a powerful reducing agent.

From the above statements, it is clear that this question turns on the fact whether this acid is mono or dibasic. Just now, the former has the preference. True we may view the formates as acid carbonites, but the anomaly of an acid, all of whose salts are acid salts, remains. A basic plumbic formate $\left.\begin{matrix}\text{Pb}''\\\text{H}(\text{C}\text{H}\text{O})\end{matrix}\right\}\text{O}$, corresponding to the acetate $\left.\begin{matrix}\text{Pb}''\\\text{H}(\text{C}_2\text{H}_3\text{O})\end{matrix}\right\}\text{O}$, if known, might have the formula $\text{Pb}''\text{C}\text{O}_2+\text{H}_2\text{O}$, plumbic carbonite.

The fact of its formation by the partial oxydation of carbon, and also, by the deoxydation of carbonic acid, are however, most cogent arguments in favor of the acid of bivalent carbon.

New Haven, Sept. 1st, 1867.

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ART. XXXI.—*Observations on Skylight Polarization in Nebraska during the month of July*, 1867; by EDWARD O. CHASE.

THE following observations were made at various stations of the U. S. Geological Survey, with an excellent Savart polariscope, of remarkable clearness. I mark the neutral points as follows: Ar., Arago's; Ba., Babinet's; Br., Brewster's.

July 1.—Cloudy.

2.—6^h 30^m P.M., Ar., Ba., both faint. Clouds below the sun.

3, 4.—Cloudy.

5.—12 M., Br., distinct. 6^h 30^m P.M., Ba., faint.

6.—Heavy rain in A.M. 6^h 30^m P.M., Ba., faint.

7.—7^h 15^m A.M. and 5^h 45^m P.M., Ba., faint.

8.—6^h 10^m A.M., Ar., distinct, Ba., faint. 6^h 30^m P.M., Ar., Ba., equally distinct.

9.—Cloudy in A.M. 7^h P.M., Ar., faint; Ba., distinct.

10.—Ba., distinct; Br., faint. Stormy in P.M.

11.—Cloudy and stormy.

12.—8^h 30^m A.M., Ba., Br., both faint. 7^h P.M., Ar., Ba., equally distinct.

13.—7^h A.M., Ar., distinct; Ba., faint. 7^h 15^m P.M., Ar., very distinct; Ba., distinct.

14.—Cloudy and rainy.

15.—6^h 30^m A.M., Ar., very distinct; Ba., faint; Br., distinct. This was the only instance in which the three points were observed simultaneously.* 7^h 25^m P.M., Ar., very distinct; Ba., faint.

16.—8^h A.M., Ba., very distinct; Br., faint. 7^h P.M., Ar., very distinct; Ba., faint.

17, 18.—Cloudy.

19.—6^h 30^m P.M., Ar., very distinct; Ba., distinct.

20.—6^h P.M., Ar., very distinct.

21.—6^h A.M., Ar., very distinct; Ba., distinct.

22.—6^h P.M., Ar., Br., equally distinct. 7^h 15^m P.M., Ar., very distinct; Ba., distinct.

23.—7^h 30^m P.M., Ar., very distinct; Ba., distinct.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the synthesis of organic acids.*—CARIUS has made the very interesting and important discovery that chlorous acid like hypochlorous acid unites directly with hydrocarbons to form chlorinated organic acids. In his first memoir the author describes the product of the action of chlorous acid upon benzol under the name of trichlorphenomalic acid, the reaction by which the new acid is formed being represented by the equation

$$\text{Є}_6H_6+(ClH\Theta_2)_3=\text{Є}_6H_7Cl_3\Theta_5+\Theta H_2.$$

* For analogous observations see this Journal, II, xlii, 112, 113.

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Trichlorphenomalic acid may be regarded as a chlorinated derivative of an acid homologous with malic acid, $\Theta_3 \left\{ \begin{matrix} \text{C}_6\text{H}_7\Theta_2 \\ \text{H}_3 \end{matrix} \right.$; the acid is colorless, crystalline and soluble in water, alcohol, benzol and ether. Its density when fused and solidified is 1·5, at 131°–132° C. it fuses, and at a few degrees higher gives off vapors of water and a new acid. Reducing agents convert the acid apparently into another acid having the formula $\text{C}_6\text{H}_{10}\Theta_5$, but with a larger excess of tin, and strong chlorhydric acid succinic acid is formed, with small quantities of another acid not yet studied. With an excess of solution of baryta trichlorphenomalic acid yields a new acid, the reaction being

$$\text{C}_6\text{H}_7\text{Cl}_3\Theta_5 + (\text{BaH}\Theta)_6 = 3\text{BaCl} + \text{C}_6\text{H}_3\text{Ba}_3\Theta_6 + 5(\Theta\text{H}_2).$$

The author terms this acid phenaconic acid, and describes a number of its salts. In addition to the crystallized trichlorphenomalic acid, an amorphous acid having the same constitution is found among the products of the action of chlorous acid upon benzol. This acid yields with reducing agents new acids free from chlorine which with their salts are also amorphous. Chemists will await with much interest the results of the researches of Carius upon the action of chlorous acid upon naphtalin which promise to connect this body with the aromatic and through this with the fatty series.—*Ann. der Chemie und Pharm.*, cxlii, 129. W. G.

2. *On the action of heat upon benzol and analogous hydrocarbons.*—Berthelot has studied the action of heat upon various hydrocarbons and has arrived at many interesting and valuable results. When benzol is passed through a porcelain tube heated to bright redness, it is partially decomposed with formation of several definite hydrocarbons which stand in very simple relations to benzol itself. The chief product is phenyl, a beautiful crystalline substance which has the formula

$$(\text{C}_{12}\text{H}_5)_2 = \text{C}_{24}\text{H}_{10} (2\text{C}_{12}\text{H}_6 = \text{C}_{24}\text{H}_{10} + 2\text{H}).$$

The author considers it as formed from benzol by the replacement of two atoms of hydrogen by an equal volume of benzol so that C_{12}H_4 $(\text{C}_{12}\text{H}_6)$ results. The phenyl obtained in this way is identical with that Fittig obtained by the action of sodium upon brominated benzol, but the method of preparation is more advantageous than that of Fittig. Above 360° C., a waxlike yellowish substance very slightly soluble in alcohol passes over, which is identical with chrysen. Berthelot gives this body the formula $\text{C}_{36}\text{H}_{12}$, $(3\text{C}_{12}\text{H}_6 = \text{C}_{36}\text{H}_{12} + 6\text{H})$ and considers it a polymer of the unknown hydrocarbon C_{12}H_4. After chrysen an orange colored resinous solid body passes over which is almost insoluble in alcohol which it however causes to fluoresce and which gives with picric acid a slightly soluble peculiar compound. In the retort there remains a fluid hydrocarbon which does not volatilize at a red heat and which on cooling gives a black and brittle bitumen. All these hydrocarbons result from the condensation of a variable number of molecules of benzol with evolution of hydrogen. Naphtalin and anthracen are not present even in small quantities. Toluol like benzol is partially decomposed by passing through a red hot tube. The products of the action by careful rectification were found to be benzol in large quantity, unaltered toluol in still larger quantity, naphtalin, a small quantity of a crystallized hy-

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drocarbon boiling at about 270° C., and a larger quantity of a fluid hydrocarbon which is perhaps benzyl $(C_1H_7)_2$ or an isomer. The boiling point then rises above 360° C., when a large quantity of an indistinctly crystallized hydrocarbon passes over mixed with a liquid. The first is anthracen $(C_{14}H_5)_2$; the others are analogues of chrysen and the last derivatives of benzol. Benzyl is derived from toluol in the same manner a sphenyl from benzol; $2C_{14}H_8=C_{28}H_{14}+H_2$. Anthracen is derived from toluol by a similar condensation and subtraction of hydrogen $2C_{14}H_8=C_{28}H_{10}+3H_2$. As, according to Berthelot's view, toluol may be derived from benzol by the substitution of marsh-gas for hydrogen, benzol $=C_{12}H_4(H_2)$, toluol $=C_{12}H_4(C_2H_2)$. Anthracen may be considered as formed by the union of the benzol residue $C_{12}H_4$ with the marsh-gas residue C_2H and has therefore the rational formula $[C_{12}H_4(C_2H)]_2$, that is, $C_{12}H_4[C_{12}H_4(C_4H_2)]$. This explains why a marsh-gas residue is necessary for the formation of anthracen and why this hydrocarbon is not formed in the decomposition of pure benzol. The formation of benzol from toluol is according to all analogy, being merely the derivation of a lower from a higher homologue. The marsh-gas residue serves to form naphtalin according to the equation

$$4C_{14}H_8=3C_{12}H_6+C_{20}H_8+3H_2.$$

When a mixture of benzol and ethylen, C_4H_4, is passed through a red hot tube the following products are obtained. (1) Styrolen $C_{16}H_8$ in large quantity well defined and without any more volatile product, except benzol; (2) naphtalin, $C_{20}H_8$; (3) another crystallizable hydrocarbon resembling phenyl and boiling at about 260° C., but forming a characteristic compound with picric acid which phenyl does not do; (4) anthracen in considerable quantity mixed with a fluid hydrocarbon, etc. The formation of styrolene may be represented by the equation

$$C_{12}H_6+C_4H_4=C_{16}H_8+H_2.$$

Naphtalin is formed by the reaction $C_{12}H_6+2C_4H_4=C_{20}H_8+3H_2$, which, according to Berthelot, leads to the rational formula, $C_{12}H_4[C_4H_2(C_4H_2)]$, so that naphtalin is formed from benzol by two successive substitutions, one of H_2 by C_4H_4 forming styrolene, $C_{12}H_4(C_4H_4)$, the second of H_2 in C_4H_4 by C_4H_2. Anthracen is formed according to the reaction $2C_{12}H_6+C_4H_4=C_{28}H_{10}+3H_2$.

which leads to the rational formula $C_{12}H_4[C_{12}H_4(C_4H_2)]$.

Pure styrolene is partially decomposed at a red heat with formation of benzol and acetylene $C_{16}H_8=C_{12}H_6+C_4H_2$.

Again benzol and acetylene heated together produce a certain quantity of styrolene, though this hydrocarbon is not the chief product. When styrolene and hydrogen, $C_{16}H_8+H_2$, are heated together in a closed tube, benzol and ethylene are formed. In this case, however, the greater part of the styrolene is directly converted into benzol according to the equation $3C_{16}H_8=4C_{12}H_6$.

Styrolene and ethylene heated together, $C_{16}H_8+C_4H_4$, yield benzol and naphtalene both in considerable quantity. The benzol results from the decomposition of the styrolene itself but the naphtalin is formed by the direct action of ethylene upon styrolene:

$$C_{12}H_4[C_4H_2(H_2)]+C_4H_2(H_2)=C_{12}H_4[C_4H_2(C_4H_2)]+2H_2.$$

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Benzol and styrolene passed together through a red hot tube gave anthracene in large quantity, together with naphtalin and a hydrocarbon resembling phenyl. The anthracene results from the direct action of the styrolene upon benzol according to the equation

$$C_{12}H_4[C_4H_2(H_2)]+C_{12}H_4(H_2)=C_{12}H_4[C_{12}H_4(C_2H_2)]+2H_2.$$

Berthelot thinks that in this case the naphtalin results from the action of the free hydrogen upon the styrolene forming ethylene and benzol, while the ethylene reacts upon another portion of styrolene to join naphtalin. Benzol and naphtalin exert no action upon each other at a red heat, but the benzol is alone decomposed. At a bright red heat anthracene is found in large quantity.

$$C_{12}H_4[C_4H_2(C_4H_2)]+3C_{12}H_4(H_2)=2C_{12}H_4[C_{12}H_4(C_4H_2)]+3H_2.$$

Phenyl heated to redness with hydrogen in a closed glass tube is partially decomposed with formation of benzol and chrysen:

$$3C_{24}H_{10}=3C_{12}H_6+C_{36}H_{12}.$$

In this case phenyl, $C_{12}H_4(C_{12}H_6)$, separates into benzol and phenylene, which last is then converted into its polymer chrysen, $C_{36}H_{12}=(C_{12}H_4)_3$. —*Comptes Rendus*, lxiii, 788, 834. W. G.

3. *On the acids of the lactic series.*—By the action of metallic zinc upon a mixture of iodid of amyl and oxalate of ethyl, FRANKLAND and DUPPA have obtained the ethers of several new acids belonging to the lactic series. The ether with the lowest boiling point, 203° C., has the formula $\text{Є}_9H_{18}\Theta_3$. The authors assign to it the rational formula

$$^{*}\left\{\begin{array}{l}\text{ЄAmHHo}\\ \text{ЄΘEto}\end{array}\right.$$

calling it amyl-hydroxalate of ethyl and regarding it as oxalate of ethyl in which one atom of oxygen is replaced by one of amyl and one of hydrogen. This body may be compared with lactate of ethyl from which it may be theoretically derived by replacing an atom of methyl by an atom of amyl.

$$\left\{\begin{array}{l}\text{ЄMeHHo}\\ \text{ЄΘEto}\end{array}\right. \qquad \left\{\begin{array}{l}\text{ЄAmH, Ho}\\ \text{ЄΘEto}\end{array}\right.$$

Lactate of ethyl. Amyl hydrate of ethyl.

The new ether is a rather oily, transparent, faintly straw-yellow liquid of density 0·9449 at 13° C., with an agreeable odor and burning taste.

A second ether formed at the same time has the formula $\left\{\begin{array}{l}\text{ЄAmHEto}\\ \text{ЄΘEto}\end{array}\right.$

The authors term it ethylated amyl-hydroxalate of ethyl. Its density is 0·9399 at 13° C.; it boils at 224°–225°, is faint yellow, and oily with an aromatic somewhat amylic odor and burning taste.

A third ether has the formula

$$\left\{\begin{array}{l}\text{ЄAm}_2\text{Ho}\\ \text{ЄΘEto}\end{array}\right.$$

The authors term this liquid diamyloxalate of ethyl; it closely resembles these last mentioned in appearance and properties. From the ethers the authors have also prepared the corresponding acids, for the description of which, however, we must refer to the original paper.

* $Am=C_5H_{11}$, $Et=C_2H_5$, $Ho=(H\Theta)$, $Eto=C_2H_5\Theta)$, &c.

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The action of zinc upon a mixture of iodid of ethyl and oxalate of amyl gives rise to a new ether which the authors term diethoxalate of amyl and which has the formula $\left\{\begin{matrix}\text{CEt}_2\text{Ho}\\ \text{C}\Theta\text{Amo}\end{matrix}\right.$. It is colorless and oily with an agreeable somewhat amylic odor and boils at 225° C. It will be readily seen that this ether is isomeric with ethylated amyl-hydroxalates of ethyl. By the action of zinc upon a mixture of iodid of amyl and oxalate of amyl the authors obtained two ethers, the first of which has the formula $\left\{\begin{matrix}\text{CAm}_2\text{Ho}\\ \text{C}\Theta\text{Amo}\end{matrix}\right.$ and may be termed diamyloxalate of amyl, while the second had the formula and properties of capronic ether $\left\{\begin{matrix}\text{CBuH}_2\\ \text{C}\Theta\text{Ago}\end{matrix}\right.$. In conclusion the authors give an elaborate and extremely interesting discussion of the classification and theory of the acids of the lactic series, for which however we must refer to the original. The following summary of their results is in their own language.

(1.) All the acids of the lactic series are essentially monobasic.

(2.) These acids are of four kinds, namely, normal, secondary, normal olefine acids and secondary olefine acids; and each of these has its own series of etheric acids in which the hydrogen of the hydroxyl contained in the positive or basylous constituent of the acid is replaced by a positive or negative compound radical.

(3.) The normal acids are derived from oxalic acid by the replacement of one atom of oxygen either by two atoms of hydrogen, or by one atom of hydrogen and one atom of an alcohol radical.

(4.) The secondary acids are derived from oxalic acid by the replacement of one atom of oxygen by two atoms of monovalent alcoholic radicals.

(5.) The olefine acids are derived from oxalic acid by a similar substitution of two positive monovalent radicals in place of one atom of oxygen with the simultaneous insertion of an olefine hydrocarbon or divalent radical C_nH_{2n} between the two atoms of oxatyl.

(6.) The acids of the lactic series stand to the acids of the acetic series in the very simple relation just pointed out by Kolbe; namely, that if in any acid of the lactic series, the hydroxyl, ethoxyl, etc., in the positive radical is replaced by hydrogen this acid is converted into a member of the acetic series.

(7.) The acids of the lactic series stand in an almost equally simple relation to the acids of the acrylic series as appears from a comparison of the following formulas: $\left\{\begin{matrix}\text{C}(\text{CH}_3)\text{HHo}\\ \text{C}\Theta\text{Ho}\end{matrix}\right.$ $\left\{\begin{matrix}\text{C}(\text{CH}_2)''\text{H}\\ \text{C}\Theta\text{Ho}\end{matrix}\right.$.

Lactic acid.

—*Ann. der Chemie und Pharmacie*, cxlii, 1. W. G.

4. *Thallic acid.*—E. Carstanjen states that when thallic oxyd, precipitated from the chlorid of ammonia, is suspended in a strong solution of potash, gently heated, and a quick current of chlorine gas passed through the liquid, it becomes of an intense violet red color, and contains potassic thallate. It may be evaporated, and even filtered through paper, but is decomposed by acids, evolving oxygen. The author is still at work upon this interesting compound.—*J. pr. Ch.*, ci, 55, June, 1867.

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5. *The new Chemical Calculus.*—On the 3d of May, 1866, Sir BENJAMIN BRODIE, Professor of Chemistry in the University of Oxford, read a paper before the Royal Society, entitled "The Calculus of Chemical operations; being a method for the investigation by means of symbols, of the laws of the distribution of weight in chemical change; Part I. On the construction of Chemical Symbols." This paper was published in the Philosophical Transactions for 1866, part II, 856, and, in abstract, in the Philosophical Magazine, IV, xxxii, 227. On the 6th of June, 1867, Prof. Brodie delivered a lecture before the Chemical Society, "On the mode of representation afforded by the chemical calculus, as contrasted with the atomic theory," which was quite fully reported in the "Chemical News" of June 14, and the "Laboratory" of the 15th, together with the subsequent discussions by Professors Frankland, Williamson, Odling, Foster, Wanklyn, Maxwell, etc. Of the critical articles called forth by Sir Benjamin Brodie's communications, those of Williamson, Chem. News, xvi, 3, July 5; of Wanklyn and Davey, Phil. Mag., IV, xxxiv, 26, July, 1867; of Kekulé, The Laboratory, i, 303, July 27; and of A. Crum Brown, Phil. Mag., IV, xxxiv, 129, August, may be mentioned. The views of Prof. Kekulé, contained in the first of a series of papers on Theoretical Chemistry, contributed to that valuable little journal, are stated so clearly, and at the same time are so just, that we reproduce the article entire. It should be remarked, however, that Professor Brodie's "Ideal Chemistry" is to be comprised in three papers, the 1st being on "The construction of chemical symbols;" the 2nd on "The theory of chemical equations;" and the 3d on "The principles of symbolic classification." Only the first of these has yet appeared. G. F. B.

On the existence of Chemical atoms; by AUG. KEKULÉ.

The question whether atoms exist or not has but little significance in a chemical point of view; its discussion belongs rather to metaphysics. In chemistry we have only to decide whether the assumption of atoms is an hypothesis adapted to the explanation of chemical phenomena. More especially have we to consider the question, whether a further development of the atomic hypothesis promises to advance our knowledge of the mechanism of chemical phenomena.

I have no hesitation in saying that, from a philosophical point of view, I do not believe in the actual existence of atoms, taking the word in its literal signification of indivisible particles of matter. I rather expect that we shall some day find, for what we now call atoms, a mathematico-mechanical explanation, which will render an account of atomic weight, of atomicity, and of numerous other properties of the so-called atoms. As a chemist, however, I regard the assumption of atoms, not only as advisable, but as absolutely necessary in chemistry. I will even go further, and declare my belief that *chemical atoms exist*, provided the term be understood to denote those particles of matter which undergo no further division in chemical metamorphoses. Should the progress of science lead to a theory of the constitution of chemical atoms—important as such a knowledge might be for the general philosophy of matter—it would make but little alteration in chemistry itself. The chemical atom will always remain the chemical unit; and for specially chemical con-

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siderations we may always start from the constitution of atoms, and avail ourselves of the simplified expression thus obtained, that is to say, of the atomic hypothesis. We may, in fact, adopt the view of Dumas and of Faraday, "that whether matter be atomic or not, thus much is certain, that granting it to be atomic, it would appear as it now does."

After these remarks, it is scarcely necessary to say that I set but small value on most of the attacks recently made against the atomic hypothesis. In many of them I see merely words and phrases, not ideas. It is, however, quite otherwise with the endeavors of those who seek to discover chemical laws independently of the atomic hypothesis. All endeavors of this kind possess great merit; and if they lead to actual results, the laws thus discovered independently of the atomic hypothesis, will be reducible to that hypothesis, and will follow as consequences from it, always supposing that the atomic hypothesis itself is true.

Brodie's 'Calculus of Chemical Operations' is an attempt of this kind. But the talented author of these speculations evidently goes too far, when he declares "that Dalton's theory is inadequate for present purposes, and that it could no longer be advantageously used to elucidate the work carried on by chemists;" and when he adds "that chemistry had got on the wrong track—off the rails, in fact."

A final verdict on these speculations cannot at present be pronounced, seeing that we have before us merely the method of drawing conclusions, and the application of this method to the construction of formulæ for the elements and for particular compounds. The author promises, indeed, that his method will present numerous and important advantages, and he hopes, further, "to be able to express, by formulæ, dynamical facts;" but all these points are reserved for future communications. We may, however, even now assert that the published results, and especially the formulæ given for the elements and compounds, possess no advantage whatever over the views now universally received. They contain, like those hitherto in use, only statics, and no dynamics, and although we are assured "that they express by symbols, the exact facts of chemistry," it is impossible not to perceive that these symbols involve an almost unlimited number of hypotheses for which there is no proof whatever.

For the elements, Brodie, as is well known, comes to the conclusion that there exist three groups, expressible by the symbols—

$$x \qquad y^2 \qquad x + y^2.$$

All elements belonging to the third group (chlorine, bromine, iodine, nitrogen, etc.) are regarded as compounds. They are not, indeed, supposed to contain two kinds of matter at present unknown in the separate state; but the much less admissible hypothesis is made that they consist of a constituent hitherto unknown in the isolated state, combined with *hydrogen*.

Such an assumption is so directly at variance, not only with all views hitherto received, but with the entire range of known facts, that it requires to be tested with all possible circumspection.

Even admitting at the outset that Brodie's speculation is founded "on a very fair amount of hypothesis," we cannot avoid seeing at the first glance that it leads to hypotheses of most astounding character, and on closer examination we are inevitably led to the conclusion that the entire

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speculation is based on pure caprice. Its foundation involves especially the three following hypotheses:

(1) Hydrogen must be assumed as the starting point.
(2) Hydrogen is an element.
(3) Hydrogen is the result of a single operation, therefore $= \alpha$.

With regard to the first, it must, at all events, be admitted that, instead of hydrogen, any other element ought to be admissible as the starting-point of the system. But if chlorine ($= \chi$) or nitrogen ($= \nu$) had been selected for this purpose, no calculation could have led to the conclusion that these bodies contain hydrogen. Now, it is clear that a system of symbols cannot be admitted as a true representation of actual facts, unless its results are independent of the particular member of the system which has been taken as a starting-point for the construction of the whole.

The second hypothesis, that hydrogen is an element, might have been admitted without remark by every chemist who regards as elements all bodies not hitherto decomposed; but the author of the speculations now under consideration is under an obligation to show grounds for such an assumption, inasmuch as he comes to the conclusion that others of the so-called elements are compounds.

The third point, and perhaps the most important in connection with results, is no less hypothetical. Why is hydrogen regarded as the result of a single operation, and not as the result of two, seeing that oxygen, sulphur, etc., are supposed to result from two operations? We are assured, "There were strong reasons for preferring the use of the system in which α was employed to present the standard amount of matter;" but these reasons are not yet made known, and therefore their value cannot be appreciated. So much, however, is certain, that, if instead of α, the expression α^2 had been chosen for the purpose just mentioned, Brodie's own form of reasoning would have led to formulæ identical in every particular with those now in use. All bodies which we now regard as elements would, or, at least, might have been found to be such; and for all compounds, the system in question would have led to the very formulæ which have long been used by the adherents of the atomic molecular theory.

The hypothesis, hydrogen $= \alpha$, is said to be the simplest that could be adopted; but it may be laid down as a general rule that, in selecting from a number of different hypotheses the one which is most probable on the ground of simplicity, it is necessary to look, not only to the relative simplicity of the hypothesis itself, but to the more or less simple character of the consequences which follow from it.

Had the author of the "Calculus of Chemical Operations" merely expressed an opinion that the formulæ which he has constructed for elements and compounds are "one of the different expressions" which, according to the principle of prime factors, are deducible from the known facts connected with relations of volume, everybody would have agreed with him. We should have perceived (though, perhaps, with some surprise) that our existing hypotheses are not the only ones capable of accounting for these relations of volume; and we should have been strengthened in the conviction that the correctness of our present theories and formulæ does not depend for its proof on volume-relations alone. But the author of this new mode of representation goes further. Among

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other things he plainly puts forward the view that many of the substances now regarded as elements contain hydrogen; and suggests that, even if the elements which are combined with hydrogen in these compounds do not exist in the free state on our earth, they may possibly exist in that state in other parts of the universe.

No one will maintain that the bodies which we now call elements are necessarily and absolutely undecomposable. But if, on the other hand, it be asserted that our existing elements are actually of compound nature, the establishment of such a proposition will certainly require more than the simple observation, that a result of the kind may possibly be deduced from a kind of reasoning founded upon hypothesis. We shall, at least, require proof that such an assumption is calculated to lead to useful results, and that it presents decided advantages over our present views. If it be maintained that many of the substances now regarded as elementary contain a substance at present unknown in the free state, combined with another body—hydrogen, for example—which we do not know in that state, we may, certainly, require the assertion to be proved by the actual separation of hydrogen from these substances. In default, however, of further knowledge, we may hold fast by the principle announced by Dalton, "that a substance, till it is decomposed, must be regarded, according to the just logic of chemistry, as an elementary substance."

II. MINERALOGY AND GEOLOGY.

1. *Notice of volume IV of the Paleontology of New York, by the Author.* 24 pp., 8vo. Albany, March, 1867.—Owing to the length of time required to complete the numerous plates of the fourth volume of his great work on the Paleontology of New York, Professor Hall has here given in advance a brief statement of the contents of this volume sometime since printed. The third volume, the text of which appeared in 1861, comprises the fossils of the Lower Helderberg and the Oriskany sandstone; and it is an exceedingly rich volume in its contents, its plates numbering nearly 140, and including a great variety of species among Crinoids, Brachiopods, Acephals, Gasteropods, Orthocerata, Trilobites and Eurypterids, all evincing a vast amount of careful research. The *fourth* volume, as the "Notice" states, takes up the following formations of the Devonian, the Upper Helderberg, Hamilton, Portage and Chemung, and as the number of species in these rocks is very great, Professor Hall confines himself here to the *Brachiopods*, deferring to a future volume the remainder of the species. We take the following facts from this Notice.

The order adopted, and the list of genera under which the species are described or discussed, are as follows:—Lingula, Discina, Crania, Pholidops (=Pseudocrania), Orthis, Streptorhynchus, Strophomena, Strophodonta, Chonetes, Productus, Strophalosia and Productella, Spirifera, Cyrtina and Cyrtia, Trematospira, Rhynchospira, Nucleospira, Retzia, Athyris, Meristella and Meristina, Pentagonia, Atrypa, Cœlospira, Rhynchonella =Stenocisma, Leiorhynchus, Leptocœlia, Camarophoria, Pentamerus, Stricklandinia, Pentamerella, Gypidula, Amphigenia and Rensselæria, Terebratula, Cryptonella, Centronella, Tropidoleptus, Vitulina.

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The Lingulæ of the Upper Helderberg are *L. ceryx*, *desiderata*, *Manni*; of the Hamilton group, *L. exilis*, *ligea*, *ligea* var., *palæformis*, *leana* (n. s.), *maida* (n. s.), *punctata* (n. s.), *nuda* (n. s.), *densa* (n. s.), *delia* (n. s.), *alveata* (n. s.), *spatulata*; of the Chemung group, *L. melia* (n. s.), *Cuyahoga* (n. s.).

The Discinæ of the Hamilton group are, *Discina minuta*, *humilis* (n. s.), *grandis*, *Randalli* (n. s.), *Doria* (n. s.), *seneca* (n. s.), *media* (n. s.), *Tullia* (n. s.), *Lodensis*, *truncata*; of the Chemung group, *Discina neglecta* (n. s.), *D. Elmira* (n. s.), *Alleghania*, *Newberryi* (n. s.).

Of the genus Crania, the *C. Aurora* (n. s.), occurs in the Schoharie grit; in the Hamilton, are *C. Hamiltonæ*, *crenistriata*, and *gregaria*, or the young of *C. Hamilitonæ*; in the Chemung, *C. Leoni*.

Of the genus Pholidops, two species, *P. areolata* (n. s.), and *P. Hamiltonæ*, occur in the Hamilton group.

The species of Orthis, of the Upper Helderberg are, *O. peloris* (n. s), *lenticularis*, *alsus* (n. s), *mitis* (n. s.), *livia*, *similis* (n. s.), *cleobis* (n. s.), *idas* (n. s.), *propinqua*; of the Hamilton, *Orthis solitaria*, *lepida*, *Vanuxemi*, *leucosia*, *Penelope*, *cyclas*, *idoneus* (n. s.), *Tulliensis*; of the Portage and Chemung groups, *O. carinata*, *Tioya* (n. s.), *impressa*, *Leonensis* (n. s.), *Thiemei*, and *leucosia?*

Under the genus Streptorhynchus, several species heretofore described are referred to *Strophomena* (*Streptorhynchus*) *Chemungensis* Conrad, under which, as varieties, are arranged *Strophomena bifurcata*, *S. arctostriata*, *S. pectinacea*, and *Orthis perversa* (Hall); *Streptorhynchus pandora* (Billings); *Orthisina arctostriata* and *O. alternata* (Hall); *Orthis inequalis* and *O. pravus* (Hall, Iowa Report). The species is extremely variable, having a great vertical and horizontal distribution, and appears under many phases.

The *Strophomena rhomboidalis* (Wahlenberg)=*S. rugosa* (Rafinesque) occurs in the Schoharie grit, and is abundant in the Corniferous limestone, but is unknown in the Hamilton and Chemung groups.

The genus Stropodonta extends throughout the series; and two species, the *S. demissa* and *S. perplana*, are found from the Schoharie grit to the Chemung group inclusive. The species recognized in the Upper Helderberg group are, *S. demissa*, *perplana*, *alveata*, *callosa*, *parva*, *crebristriata*, *inequiradiata*, *Patersoni*, *hemispherica*, *inequistriata*, *ampla*; in the Hamilton group, *S. concava*, *perplana* Conrad (which has been described under the names *Strophomena perplana*, *S. pluristriata* and *S. delthyris* Conrad; and as *S. nervosa*, *S. crenistriata* and *S. fragilis* Hall); *demissa*, *nacrea*, *inequistriata*, *jumia*; in the Chemung, *S. Cayuta* (n. s.), *mucronata*, *cælata* (n. s.), *perplana* var. *nervosa*, *demissa*.

In the genus Chonetes, we find verified in a very satisfactory manner the observations made by Count von Keyserling, in regard to the direction of the tubes or spine-bases in the area of the ventral valve. These tubes are directed from the hinge-line toward the apex of the valve, and parallel to the sides of the triangular fissure. They appear on the crest of the area as little pustules or elongated tubular spines, which may be either vertical to the hinge-line or directed outward. The species of the Upper Helderberg and Hamilton groups are, *C. hemispherica*, *arcuata*, *acutiradiata*, *lineata*, *Yandellana*, *mucronata*, *deflecta*, *pusilla*, *setigera*, *scitula*, *lepida*, *coronata*, *Logani*.

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The occurrence of the *C. Logani* in the Tully limestone carries back the appearance of this species to a much earlier epoch than had heretofore been known. The species is not known in the Chemung group within the State; though found in the sandstones of the same age in Ohio, and in the beds at the base of the Burlington limestone in Iowa and Illinois.

In the Chemung group we have the recurrence of *Chonetes scitula*, *C. lepida* and *C. setigera;* with a new and remarkable species, the *C. muricata*, which has the apex truncated and the surface of the ventral valve ornamented with spines, but having the vascular markings peculiar to the genus.

Under the head of Productus and Strophalosia, the relations of these genera and of the genus Aulosteges are discussed. The Devonian species, sometimes referred to Strophalosia, are shown to have a narrow area, but with internal vascular impressions like Productus. The absence of an area in the genus Productus is not uniform, as is shown in *P. costatus* of the Carboniferous system in America; and the same has been shown by Mr. Davidson to be true of *P. sinuatus* and *P. semireticulatus* of Europe.

In comparing the American Devonian forms of Productidæ with the Strophalosia of the Permian system, the former have a greater width on the hinge-line, and in this respect more resemble typical Productus; while the narrow cardinal area and hinge-teeth assimilate them with Strophalosia. Notwithstanding this feature, the vascular markings are like Productus. At this epoch we have the earliest known appearance of these forms, the type of which becomes extravagantly developed in the Carboniferous period, and, waning during the Permian epoch, is presented for the most part in degenerate modifications of the typical forms. Although we cannot shut our eyes to this fact of development to what may be termed the perfection of the type, and its more abrupt decline, we are either compelled to extend the characters of Productus so as to cover the two forms or modifications indicated, or else to propose a distinct designation. The latter course has been adopted, and the name Productella is proposed for the strophaloid Productids of the Devonian period.

The subgenus Productella is compared as follows, in Pal. N. Y., vol. IV, page 153: "These shells differ from Strophalosia in the extremely narrow linear cardinal area, greater extension of the hinge-line, more extreme arcuation or ventricosity of the ventral valve in many or most of the species, and especially in the direction and termination of the reniform vascular impressions, which resemble those of Aulosteges and of some species of Productus. It differs from Productus in the constant presence of an area, hinge-teeth and sockets."

The Productellæ of the Upper Helderberg and Hamilton groups mentioned are, *P. subaculeata*, *navicella*, *Shumardiana*, *spinulicosta*, *truncata*, *dumosa*, *exanthemata*, *Tullia* (n. s.), *subalata;* of the Chemung group, *P. hirsuta*, *hirsuta* var. *rectispina*, *Boydii*, *rarispina*, *lachrymosa*, *lachrymosa* var. *linea*, *lachrymosa* var. *stigmata*, *speciosa*, *striatulata* (n. s.), *hystriculata*, (n. s.), *costatula* (n. s.), *costatula* var. *strigata*, *arctirostrata*, *bialveata* (n. s.), *onusta* (n. s.).

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So great a number of fossils of this type in many localities, and particulary in the western part of the State, give a Carboniferous aspect to the strata; and leaving out a few forms which gradually disappear in the western extension of the formation, the paleozoic evidence might be regarded as decidedly favoring this view. The distinction, however, between Devonian and Carboniferous faunas is based as often upon geographical as chronological relations.

The species of Spirifera in the Upper Helderberg group are, *S. duodenaria*, *macra*, *raricosta* and *Grieri*, occurring both in the Schoharie grit and in the limestone above; which latter likewise contains the following species: *S. gregaria*, *Oweni*, *acuminata*, *macrothyris*, *unica* (n. s.), *disparilis*, *varicosa*, *varicosa* var., *segmenta*, *arctisegmenta*, *euruteines*, *euruteines* var. *fornacula*, *Mannii*, *divaricata*. *fimbriata*. The last named species occurs also in the Oriskany sandstone and Schoharie grit. Several of the species indicated above are known in their perfect condition only in the limestones of this age in Ohio and adjacent States of Indiana and Kentucky.

In the Hamilton group, the most abundant and widely distributed species is *Spirifera mucronata*, besides there are, *Spirifera Tullia* (n. s.), *formosa*, *sculptilis*, *ziczac*, *granulifera*, *Marcyi*, *medialis*, *medialis* var. *Eatoni*, *angusta*, *macronota*, *subumbona*; in the Portage group only the *Spirifera lævis*, which has much the general aspect of a Carboniferous form; in the Chemung, *S. mesacostalis*, *mesastrialis*, *disjuncta*, with its numerous synonyms and the species represented in a great variety of aspects, *alta* (n. s.), *præmatura* (n. s.).

The chapter on Spirifera is concluded with some remarks upon the geological and geographical distribution of the species of Spirifers, the hinge-structure, etc., which have already been published.*

The name Ambocœlia is continued, being regarded as presenting sufficient distinction from Spirifera; and in the Hamilton group are recognized, *Ambocœlia umbonata*, *A. preumbona*, in the Chemung group, *A. umbonata* var. *gregaria*.

On page 263 of the volume are some observations on the genus Cyrtia of Dalman, and Cyrtina of Davidson. So long since as in 1858, Mr. Davidson, in his Introduction to the Study of the Brachiopoda, had expressed some doubts as to the value of the genus Cyrtia of Dalman; and later investigation had shown that the typical species of that genus does not differ from Spirifera. At the same time, some forms usually referred to the genus Cyrtia possess a peculiar modification of the dental plates, with a largely developed median septum and punctate structure of the shell. For these forms, Mr. Davidson has proposed the name Cyrtina. All the American species heretofore referred to Cyrtia, and which have been reëxamined, prove to belong to Cyrtina. Of these we have *C. pyramidalis* in the Niagara group, *C. Dalmani* in the Lower Helderberg group, and *C. rostrata* in the Oriskany sandstone.

Three species are described in the present volume from the rocks of New York, viz: *Cyrtina biplicata*, from the Schoharie grit; *crassa* (n. s.),

* The paper by Professor Hall alluded to on page 408 of vol. xliii of this Journal, was not a newly written article as might be inferred from the note, but as he states in introducing it, a citation from the pages of his volume IV.

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from the Corniferous limestone; *Hamiltonia*, from the Hamilton group; and a variety of the latter from the Chemung group. A species from the Hamilton group in Iowa, *C. curvilineata* (?), is noticed.

The genus Trematospira, proposed in vol. iii, and published in the Tenth Report on the State Cabinet, is represented in the Hamilton group by two species: *T. gibbosa*, *hirsuta*.

The genus Rhynchospira is represented only by a single species, the *R. lepida*. The *R. nobilis* from the Hamilton group, formerly referred to this genus, presents some points which render its generic relations more nearly with Trematospira.

The genus Nucleospira is represented by a single species, the *N. concinna*.

Under Athyris we have the *Athyris spiriferoides*, an abundant and widely distributed form in the Hamilton group; and the *Athyris vittata*, occurring in the limestone of the Upper Helderberg group; and also in the Hamilton group of Iowa. A second species in the Hamilton group is the *Athyris cora*. In the Chemung group, we have the *Athyris angelica* and the *A.? polita*.

The genus Meristella, separated from Athyris on account of its different external characters and muscular impressions, is represented by *M. nasuta*, *scitula*, *Doris*, *Barrisi*, *Haskinsi*, *rostrata*, *Meta* (n. s.). In the Chemung group, there are a few casts of an undetermined species. The *Meristella unisulcata* of the Corniferous limestone is referred to the subgenus ? Pentagonia of Cozzens, and its varieties of form illustrated. The species is of rare occurrence in the Hamilton group.

The genus Atrypa, as applied to forms strictly congeneric with *Atrypa reticularis*, embraces but few species, and these are regarded by some paleontologists as merely varieties of still fewer species. In this volume, the *Atrypa impressa* of the Schoharie grit is continued as a distinct species; although resembling the *A. reticularis* in general features, it presents a wide departure from the forms of that type in other strata; and if we are to regard these varieties as due to physical causes, the nature of the sediments, etc., then there is reason to believe that in other instances the same physical influences have produced changes which are recognized without hesitation as of specific value. The *Atrypa reticularis* in its various phases, occurs in the Corniferous limestone, the Hamilton and Chemung groups. The *Atrypa spinosa* (Hall), or *Atrypa aspera* (Schlotheim), is recognized as a very distinct and well-marked species, occurring in the Corniferous limestone, Hamilton and Chemung groups. In the Hamilton group it is more abundant and better preserved than in any other formation; and occurring in the same beds with *A. reticularis*, it never approaches that one in character; there is no difficulty in distinguishing the one from the other; and the same is true of these forms in the Chemung group. It is also observed that the same distinction between these species exists in Illinois and Iowa. The *Atrypa hystrix* of the Chemung group is likewise regarded as a distinct species, though possessing many features of an extravagant *A. spinosa*. A species of Atrypa, closely resembling the *Atrypa marginalis* of Dalman, occurs in the Corniferous limestone. This species, *Atrypa pseudomarginalis*, is of rare occurence in the rocks of New York.

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A single Cœlospira occurs in the Corniferous limestone, which, so far as known, possesses no characters differing from *Cœlospira concava* of the Lower Helderberg group.

Under the Family Rhynchonellidæ, the species usually referred to the genus Rhynchonella are shown to differ from recent species referred to that genus; while at the same time the internal structure and appendages of the typical species of the genus (*R. loxia*) remain unknown or unillustrated. Under these circumstances, the name Stenocisma, proposed by Mr. Conrad in 1841, is revived, and applied to most of the rhynchonelloid forms of the rocks under consideration. Since, however, Rhynchonella has come to be so well known, and many of the species have been described under the generic designation, the name is still retained. The species of the Corniferous limestone are, *Rhynchonella* (*Stenocisma*) *Tethys*, *Billingsi* (in place of *R. thalia* of Billings, name preoccupied) *Carolina* (n. s.), *Royana* (n. s.); of the Hamilton group, *R.* (*Stenocisma*) *Horsfordi*, *Sappho*, *congregata*, *prolifica* (n. s.), *dotis* (n. s.), *carica* (n. s.); of the Chemung group, the following species are described: *Rhynchonella* (*Stenocisma*) *eximia*, *Stephani* (n. s.), *duplicata*, *contracta*, *orbicularis*, *Sappho* var.

The genus Leiorhynchus is retained for such forms as *L. limitaris* and *L. quadricostata* which present, among other distinguishing features, a division or bifurcation of the plications on the mesial fold and sinus. The species recognized as belonging to this genus are *L. limitaris*, *L. mysia* (n. s.), *L. quadricostata*, *L. multicosta*, *L. iris* (n. s.), *L. Kelloggi* (n. s.), *L. sinuatus* (n. s.), *L. mesacostalis*, *L. globuliformis*, *L. dubius* (n. s.).

Under the genus Leptocœlia, the *L. acutiplicata* is the only species recognized.

The genus Camarophoria has been observed in a single smooth species, the *C. eucharis*, from the Upper Helderberg limestones.

Some of the pentameroid forms, heretofore referred to the genus Pentamerus, are placed under new genera, on account of certain peculiarities of their internal structure.

Pentamerella includes *P. arata* (=*Pentamerus aratus*), *P. papilionensis* (=*Pentamerus papilionensis*), *P. micula* (n. s.), *P. obsolescens* (n. s.), and *P. dubia* (=*Spirifer dubius* Hall, Thirteenth Report on the State Cabinet); Gypidula includes *G. occidentalis* (=*Pentamerus occidentalis* Hall, Geol. Report of Iowa), and *G. lævinscula* (n. s.); Amphigenia is proposed to include the original *Pentamerus elongatus* of Vanuxem, which possesses characters unlike any other genus of the pentameroid family; the *A. elongata*, and a variety *undulata*. The species formerly described as *subtrigonalis* appears to be only a variety of the *A. elongata*. Rensselæria is recognized with doubt, and a single species, *R.* ? *Johanni*, is noticed from the rocks of the age of the Upper Helderberg group in Iowa. The genus Terebratula is recognized in the following species: *T. Lens*, *T. Sullivanti* (n. s.), *T. harmonia* (n. s.), *T. Ræmingeri*, *T. Elia* (n. s.), *T. jucunda* (n. s.), *T. navicella* (n. s.), *T. simulator* (n. s.).

The genus Cryptonella includes *Cryptonella rectirostra*, *C. planirostra*, *C. Iphis* (n. s.), *C. Lincklæni*, and a doubtful form, *Cryptonella* (*Terebratula*) *eudora*, from the Chemung group; and Centronella, the *C. glansfagea*, *C. alveata*, *C. impressa* and *C. glaucia* (n. s.).

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A further study of the genus Tropidoleptus has revealed certain features of internal structure, which seem to ally it with the Terebratulidæ. The *T. carinatus* is the typical species of the genus. A western form has been described under the name *T. occidens.*

The relations of the genus Vitulina are not fully established. The shell-structure is punctate, with a papillose surface, a high area on the ventral valve, with a large triangular fissure. The genus embraces a single species, the *Vitulina pustulosa.*

The volume contains critical remarks on many of the various genera, citations from some of which, Professor Hall gives in the Notice of the volume.

The labors of Professor Hall are contributing very largely to the progress of American and general Geology and Paleontology, and it is to be hoped that his engravers will do their work as rapidly as is consistent with its accuracy and beauty, that the world may speedily reap the full benefit of his extended researches.

2. *On the Paleontology of Victoria, South Australia;* by FREDERICK McCOY.—The author, after treating of the distribution and characteristics of the Post-tertiary, Tertiary, Cretaceous, and Triassic of Victoria, and pronouncing the Australian coal beds Mesozoic, makes the following observations on the Paleozoic formations of the country.

Carboniferous.—The sandstones of the Avon in Gippsland are the only traces of this formation that I can recognize in Victoria, and the only fossil I have seen from it is the *Lepidodendron*, referred to above, identical with that recognized by me many years ago from New South Wales, and which I have lately seen also from Queensland.

Devonian.—It is with great pleasure I announce the fact of my having been able satisfactorily to determine the existence of this formation also in Australia, the limestone of Buchan in Gippsland containing characteristic corals, Placodermatus fish, and abundance of the *Spirifera lævicostata*, perfectly identical with specimens from the European Devonian limestones of the Eisel.

Upper Silurian.—I have been able to recognise the Mayhill sandstones and the Wenlock rocks with certainty in many localities in Victoria. At Broadhurst Creek, for instance, the beds are filled with numbers of the *Phacops* (*Odontochilæ*) *longicaudatus* exactly as the corresponding English beds of Cheny Longville are in Shropshire; and here, as in every part of the northern hemisphere, the *Spirigera reticulata* is the commonest Brachiopod, and many others identical with species of England, Bohemia, and North America occur with it.

The Ludlow rocks are indicated by the *Orthoceras bullatum*, and a series of starfish closely representing those of the English Ludlow beds, together with a beautiful new *Homalonotus* (*H. Harrisoni* M'Coy), which I have named after the discoverer, as well as the *Graptolites Ludensis.* The *Hemithyris diodonta* Dal. is as abundant in the Mayhill sandstone of Victoria as in the corresponding English beds at Malvern, and the same appearance of oblong smooth *Pentamerus* (*P. Australis* M'Coy) mark this sandy base of the Upper Silurian in Victoria as in England and Wales, and North America.

Cambrian of Sedgwick, Lower Silurian of Murchison.—It is to this

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period that I have been able without hesitation to refer the whole of the slates containing gold-quartz veins or reefs in Victoria, and all the slates containing these gold-bearing veins are identical in age and character with those of North Wales, in which the Romans worked the gold mines of Gogo Fau.

Not only are the majority of the fossil *Graptolites* found in the Welsh Llandeilo Flag, and of the corresponding Cumberland and Scotch slates, also found in those beds in Victoria, but we have in these formations the most extraordinary proof of the unexpected fact which I announced on a former occasion, that there was in the Cambrian or Lower Silurian period a nearly complete specific uniformity of the marine fauna, not only over the whole northern hemisphere, but across the tropics, extending to this remote temperate latitude of the southern hemisphere.

In the slates of the goldfields the principal fossils are *Graptolites*, and, what is very extraordinary, I have here identified specifically nearly the whole of the series of remarkable compound *Graptolites* first made known from the similar slates of Canada by the researches of Professor Hall. Many of the species have not yet been recognised in any but the Canadian localities in the northern hemisphere, and to find nearly the whole series here is most interesting, as their powers of locomotion could only be exercised in the short ovarian and free stage, so that, except on the supposition of a uniform marine fauna at this earliest zoological period of the earth's history, we could scarcely account for this width of distribution, and still less so of the littoral or shallow-water mollusca which accompany them in other beds. The *Diplograpsus mucronatus* Hall, so common in the Utica slates of New York, I find in equal abundance here in the slates of Bendigo or Sandhurst, and with it abundance of the *D. quadrangularis* M'Coy, completely identical with those I described many years ago from the slates of Dumfriesshire. The *Diplograpsus pristis* (His. sp.), also occurs in these same slates, mixed with the others, as in Sweden, Bohemia, and Scotland, but in certain different sandy beds it covers the whole of the planes of deposition in millions, to the exclusion of everything else, exactly as it does in certain beds of the English Caradoc sandstone near Church Stretton. In some localities these are replaced by great numbers of the Bohemian *Diplograpsus palmeus* Barrande, on the upper end of many specimens of which I find a large smooth pear-shaped or heart-shaped appendage, which I believe to be an ovarian vesicle. I should remark that I have observed exactly the same appendage (bearing out, I think, the idea which I have supported formerly on other grounds,* of the affinity of the *Graptolites* with the *Hydroida*) in specimens of this species from the slates of the typical locality in Bohemia, when carrying out the direct careful comparisons of specimens of species, which I state to be identical in Victoria and other countries; so the frequent observation of this apparent ovicell in the Victorian specimens does not at all affect the identity of this species with that of the basin of Bohemia, of which there can be no doubt. The *D. ramosus* Hall is also in our slates identical with those of the Utica slate of New York. Of the group of compound Canadian *Graptolites*, the commonest in the Victorian goldfield slates of many localities is the

* British Palæozoic Rocks and Fossils.

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Didymograpsus caduceus Salt., first described from the Quebec slates. In many localities the specimens of this species are as small as the first described Canadian ones, but in others they acquire a greatly increased size, occasionally twice the length and nearly three times the width, and the angle of divarication of the two branches varies from 5° to 70°.

This is usually accompanied by the *D. serratulus* Hall, identical with those of New York slates, and generally also by the very large Canadian *D. bryonoides* Hall, which it is possible may be hereafter found to be the perfect development of my *G. latus*. The *D. nitidus* Hall is more rare, but perfectly identical with the Canadian types. The *Graptolites gracilis* Hall, identical with the New York and Canadian species, is one of the rare compound forms. The curious radiating compound forms, which created so much astonishment when published first by Professor Hall in his Decades of the paleontology of this part of Sir H. Logan's geological survey of Canada, I find in just as great abundance in the slates of the same age in Victoria. *D. octobrachiatus*, *D. quadribrachiatus*, and *D. Logani* Hall, are, especially the latter, not uncommon in many of the goldfield localities. The curious Canadian quadrifid graptolite, named *Phyllograptus Typus* by Hall, is one of our most abundant Australian Graptolites; but, although sometimes upwards of an inch in length, small specimens, I find, on comparison with Swedish specimens of the *G. Folium* of Hisinger, are perfectly identical therewith; and further, on carefully comparing Bohemian specimens of the *G. ovatus* of Barrande with the Swedish *G. folium*, I have no doubt they belong to one variable species, and are identical with the smaller examples of the Australian and Canadian species; and further, that the European specimens are truly quadrifoliate, like Hall's *Phyllograptus;* and in this way the difference in the different descriptions, as to the width of the midrib, becomes intelligible.

As a general rule, the graptolite slates in every part of the world contain no other fossils. I many years ago discovered in Wales, near Builth, the only shell I ever heard of in graptolite slates (the *Siphonotreta micula* M'Coy), and I was greatly surprised to recognize it also in Victoria, in the Deep Creek section. The crustacean genus *Hymenocaris* is represented by a new species, *H. Salteri* M'Coy, found in most of the graptolite slate localities.

In a different set of sandy, marly, and mud-stone beds—as at Woori Yallock, Yarra—we find an extensive series of the genera and many of the species of corals, trilobites, and mollusca of the "Bala beds" of North Wales; species of *Favosites*,* *Palæopora*, *Calymene*, *Phacops*, *Beyrichia*, *Strophomena*, *Leptagonia depressa*, *Spirigera reticularis*, *Orthis elegantula*, the characteristic little genus *Cucullella*, *Murchisonia*, *Cornularia*, &c.; and some species new, and some identical with British ones, forming a group so completely reproducing the well known Bala beds as to afford a second case in support of the view of the general specific identity of the marine fauna over both hemispheres of the whole world in the earliest paleozoic times.

* It is worthy of remark, that as on the continent of Europe the Devonian genus *Pleurodictyum* has now been found in Silurian strata, so in those beds in Victoria I find a new species (*P. megastoma*, M'Coy), with cells half an inch in diameter.

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It is curious that I have not yet seen any trace of the genus *Trinucleus* in Australian beds, nor *Ampyx*, while all the above-mentioned genera of Trilobites, with *Acidaspis*, *Chirurus*, &c., are well marked.

I can scarcely close this part of the subject without drawing attention to the curious confirmation offered in Victorian geology of the view of Professor Sedgwick and myself, that there was a real systematic line of division between the Upper Silurian and the Cambrian and Lower Silurian, at the base of the Mayhill sandstone, and over the Caradoc sandstone—the Mayhill sandstone which we first defined and demonstrated to have Upper Silurian fossils only, and the true Caradoc sandstone full exclusively of Lower Silurian or Cambrian types; the previous confusion of these two sandstones, from the mingling erroneously of the fossils in collections, having given Sir Roderick Murchison the erroneous impression that his Upper and Lower Silurian groups of fossils (the distinctness of which he himself was the first to point out) were mixed together in the Caradoc sandstone, and that consequently the Bala beds, identical in fossils with those of the Caradoc beds (although formerly recognized by him as the type of the Cambrian system), could not be separated paleontologically from the Upper Silurian group. The Mayhill sandstone was one of the first formations I recognized on landing near Melbourne, with the usual Upper Silurian fossils; and it is now found here, as in Wales, to be slightly unconformable to the Cambrian or Lower Silurian, forming the obvious base of the former, and totally distinct in fossils from the latter.

3. *Note by F. B. Meek to his Review of Prof. Geinitz in regard to Nebraska fossils.* (See p. 170).—Since writing the remarks on the Nebraska fossils investigated by Prof. Geinitz, an extensive collection of specimens obtained at Nebraska City by Dr. Hayden and myself, during the progress of the geological survey of that state (now under his charge) and placed in my hands for investigation, enables me to give the following additional information.

On page 182, I expressed the opinion, from the examination of some rather imperfect specimens shown to me by Dr. White from Iowa, that the species referred by Prof. Geinitz to the so-called *Avicula pinnæformis*, is not only specifically distinct from that shell, but that it probably belonged to the distinct genus *Pinna*. A careful examination of a fine series of much better specimens from Nebraska City confirms my first conclusion in regard to its being a distinct species, and at the same time leads to the conclusion that it is an *Aviculopinna*, since its beaks are slightly removed from the extreme point of the shell, so as to leave a very small lobe in front, best seen in internal casts. It differs, however, specifically from the European *A. pinniformis*, not only in never attaining one-fourth as large a size, in its more uniform outline, and its much more nearly terminal beaks, but in being without any *traces* of radiating striæ, while its concentric markings differ in being strong, regularly disposed, rather distantly separated and abruptly elevated lines or lamellæ, unconnected with concentric wrinkles on any part of the valves; instead of fine crowded striæ, gathered into wrinkles on the ventral region. It is also provided on the upper half, with two or three large, very obscure radiating folds not seen on *A. pinniformis*, while its posterior margin also differs in being slightly sinuous just under the extremity of the hinge.

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For this species I would propose the name *Aviculopinna Americana.* As might be expected, the very thin substance of this shell is seen under the microscope to have a prismatic structure, like that of other types of the *Aviculidæ.*

I avail myself of this opportunity to correct a few typographical errors that occur in my remarks on the Nebraska fossils in this number of the Journal.

Page 173, fifth line from top, for "respecting" read representing. Page 177, seventeenth line from top, for "thus far" read this far. Page 180, twenty-second line from bottom, for "they are," read it is. Page 184, sixth line from top, strike out the ? after *Rhynchonella.*

4. *Note on the Corundophilite of Chester, Mass.*—In a note on page 258 the writer has alluded to observations on the optical characters of the Chester chlorite made by Mr. Descloizeaux. Mr. Descloizeaux communicated his results to the writer in a letter dated Paris, Jan. 29, 1866, or a year and a half since. They are as follows.

Corundophilite is a clinochlore, in macled plates or crystals. The divergence of the axes is very variable, they being sometimes united, and at others widely separated. The bisectrix is *positive*, and distinctly inclined to the plane of cleavage or the surface of the plates. In one good plate I found 2E (or angle of divergence observed in the air) $=65°$ for white light at 22° C. On heating to 200° C., the angle was increased from 3 to 4 degrees, a characteristic distinguishing clinochlore from pennine, which is always insensible to heat. The dispersion of the optical axes is quite distinct and $\rho<v$. The hyperbolas are bordered by red interiorly and green exteriorly.

5. *Note on the optical characters of different micaceous minerals called Margarite;* by Mr. DesCloizeaux. (From a letter to J. D. Dana, dated Paris, August 15, 1867).—(1.) In 1847 I received from the vicinity of Sterzing, a foliated mineral having the plates a little concave, of white color and pearly luster, and well named *perl-glimmer*, which has the optical axes distinctly united.

(2.) The small specimen sent me recently by Mr. Dana as the original margarite is identical with one which had been sent me after 1848; it is in white laminæ mixed with some green clinochlore, and was regarded at that time as chloritoid. The laminæ are very much macled, and the divergence of the optical axes is accordingly very variable. I have found for the red ray, at 20° C. with

my specimen	2E=126° 24′;	in another plate, =117° 30′.
Mr. Dana's specimen	2E=109° 32′;	" " " 128° 38′.

The dispersion is very feeble, and it is rendered quite indeterminable by the numerous interlacings of the laminæ. The plane of the optical axes appears to be parallel to the longer diagonal. [This is the margarite of p. 259.]

The clinochlore mixed with the margarite is macled, with distinct dispersion ($\rho<v$), and with strong double refraction. A plate gave me

2E=60° 48′ for the yellow ray.

(3.) In 1863 I received from Rammelsberg, under the name of *Baryt-glimmer* [the Œllacherite of p. 256] a so-called margarite from Pfitsch, which is white and pearly, and has been analyzed by Œllacher. The

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plates are very transparent, the double refraction strong, the dispersion feeble with $\varrho > v$, and orientation of the optical axes uncertain because of the irregular contour of the laminæ. I have found, at 20° C.

$2E = 79° 21'$ for the red ray; $2E = 78° 45'$ for the blue,

angles which correspond with those of ordinary potash mica.

6. *Eozoon Canadense in Finland.*—Prof. Pusirevski reports the occurrence of the Eozoon Canadense in limestone at Hopunwara in Finland. A lower and upper system of schistose metamorphic rocks have been distinguished. In the lower division of the upper system, at Pusunssari and Hopunwara near Pitkäranda occurs a limestone with serpentine, and the serpentine affords small nodules consisting of parallel layers which have the structure of the Eozoon. The facts are stated to prove that a large part of the rocks of Finland are Laurentian, and that the upper and lower systems probably correspond to the upper and lower groups of Canada.—*Bull. Acad. St. Petersbourg*, x, 151.

7. *Geological Observations in Colorado.* (Colorado Transcript, July 24, 1867.)—The late railroad surveys on Dry and Boulder creeks, St. Vrain, Big Thompson and Cache-a-la-Poudre rivers, and on the South Platte, under Capt. E. L. Berthoud, have shown that the Cretaceous strata on the east slope of the Rocky Mountains, extend eastward from the mountains at least four hundred and seventy-five miles; that in the upper beds, extending some seventy-five miles from the Rocky Mountains, coal of good quality can be found in large fields, which near the mountains in Jefferson county are covered on its west border by almost horizontal Tertiary beds, and through which extensive outcrops of Cretaceous coal occur.

8. *Geological Survey of Nebraska.*—By appointment from the General Government, the geological survey of Nebraska has just been commenced under the direction of Professor F. V. Hayden. Dr. Hayden is in his old familiar field, where he has explored in former years with great success, and we may expect very valuable results from his investigations. The experienced paleontologist, Mr. F. B. Meek, is associated with him in the work. The territory of Nebraska lies directly west of the state of Iowa, the survey of which state is going rapidly forward under Dr. C. A. White, its able state geologist; and this again directly west of Illinois, whose geological survey under Dr. Worthen has already made great progress, as shown in the admirable volumes recently published. The Reports of these regions when completed, will extend our knowledge of the geology of the continent on this side of the Rocky Mountains to 104° W. It is to be regretted, however, that the great and rich states of Ohio and Indiana yet remain but very imperfectly explored.

III. BOTANY.

1. *Manual of the Botany of the Northern United States, including the district East of the Mississippi and North of North Carolina and Tennessee, arranged according to the natural system;* by ASA GRAY, Fisher Professor of Natural History in Harvard University. Fifth edition, with twenty plates illustrating the Sedges, Grasses, Ferns, etc. New York: Ivison, Phinney, Blakeman & Co. Chicago: S. C. Griggs & Co. 1867, 8vo, pp. 701.—The former editions of this Manual have been duly noticed in this Journal. The first edition was published in 1848, and was at once accepted as the standard Flora of the region it embraced.

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The work was entirely rewritten for the edition of 1856, and was revised upon the stereotype plates, some pages also being added, for the third edition (1862), and for the fourth (1863). The fifth edition has been mostly rewritten, several month's labor having been expended upon it.

The *Garden Botany* is excluded from this edition, but will be incorporated into a separate, more elementary work entitled *Field, Forest*, and *Garden Botany*. The *Mosses* and *Liverworts*, also, which were contributed to the previous editions by Mr. Sullivant, are now omitted, but the hope is expressed that these orders, together with the *Lichenes*, by Prof. Tuckerman, and perhaps the remaining orders of Cellular Cryptogamia, may before very long be published in a supplementary volume.

To the fourteen plates at the end of the volume, illustrating the genera of Grasses and Ferns, are now added six new ones, from original drawings by Sprague, to show the structure of the genera of Cyperaceæ. By the help of these accurately drawn figures the student will be able to identify easily the genus of any native or introduced plant belonging to these somewhat difficult orders.

While the general plan of the work is otherwise unchanged, a comparison of this volume with its predecessor shows that the learned author has taken new views of several natural orders, and that the generic and specific descriptions generally have been studied anew, and most faithfully compared with the plants as they exist in nature.

Among the changes in the natural orders to be particularly noticed is the uniting of *Nelumboneæ* and *Cabombaceæ* with *Nymphæaceæ*. This had already been done by Bentham & Hooker, and indeed we find *Nelumboneæ* made a tribe of *Nymphæaceæ* in DeCandolle's *Systema Vegetabilium*. But why not keep the name *Nelumbo* as originally written by Adanson in 1763, and adopted by Gærtner in 1788, a year before it was changed to *Nelumbium* by Jussieu? It would then accord with *Negundo*.

Another noticeable change is the restoration of *Tropæolum*, *Impatiens* and *Oxalis* to *Geraniaceæ*, in which order they were placed as "*Genera Geraniis affinia*" by its founder Jussieu. In the same order Dr. Gray has placed *Floerkea* also, in the whole arrangement following pretty closely the views of Bentham & Hooker. The same authors had already included *Ribes* as well as *Parnassia* in *Saxifragaceæ*. The clustered staminodia of *Parnassia* are perhaps peculiar to the genus, but there are single staminodia or glands alternate with the stamens of *Francoa* and *Tetilla*, and the multifid lobes of the disk in *Brexia* is perhaps somewhat similar. Nor does *Ribes* alone produce berries, for they occur in several genera of *Escalloniea*.

Haloragea is separated from *Onagraceæ*, the points of difference being numerous and well marked. *Loganiaceæ* is recognized as a natural order and is placed next after *Gentianaceæ*. *Liliaceæ* is much extended, *Trillideæ* and *Melanthieæ* being regarded as tribes, the genera *Prosartes* and *Streptopus* placed in *Asparagineæ*, and *Narthecium* in *Lilieæ*. Some such consolidation of orders in the lilial alliance has seemed inevitable ever since it was shown by Dr. A. W. Chapman that the anthers of *Lilium* itself are extrorse in the bud.

The alterations in generic nomenclature and the uniting or dividing of genera are not very numerous, and every such change was apparently demanded by the progress of botanical science.

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Atragene is reunited with *Clematis*, and *Pulsatilla* with *Anemone*. *Iodanthus* and *Turritis* go into *Arabis*, and *Arenaria* now includes *Alsine*, *Mœhringia* and *Ammadenia* (*Honkenya*). *Sanguisorba* is referred to *Poterium*, the characters of *flowers perfect, stamens few, carpel single, and seeds mostly smooth* not being constant, and the habit being the same in both. The restoration of the Linnæan genus *Houstonia* is most welcome, and we may now call the little *Bluets* by the name they bore when we first knew and admired this pretty flower. The Linnæan name *Ruellia* replaces the later one of Nees, *Dipteracanthus;* and *Stylisma* is referred to *Bonamia*, the characters of *styles somewhat less united* and *stamens less exserted* not justifying the separation of the American from the Madagascar species. *Benzoin* of Nees becomes *Lindera* of Thunberg, and the old genus *Habenaria* is restored to North American botany, for *Gymnadenia* and *Platanthera* both yield their places as distinct genera, Dr. Gray here returning to the view which he proposed in this Journal, in 1840.

A few specific names are altered, especially where older but less known names have been recently identified with well known species, as for instance *Ranunculus multifidus* (Pursh, 1814,) is substituted for *R. Purshii* (Richards, 1823), or where an American plant is proved to be identical with an older European species, as is *Viola Muhlenbergii* with *V. canina*. Not a few plants which were utterly unknown when the fourth edition of the Manual was published, in 1864, are now for the first time made known to science, and many more which were known to inhabit adjacent, or sometimes distant regions have been recently detected within our limits. A new *Polygala*, an *Aster*, a *Lobelia*, a *Pyrola*, two *Orchids* and two species of *Isoetes* are among the former, and the latter class includes a *Stellaria*, a *Parnassia*, another *Aster*, *Calluna vulgaris*, an *Ilex*, nearly a score of *Carices*, and several *Ferns*. In 1856 the indigenous Flowering plants and Acrogens known to inhabit the region covered by this Manual amounted to 2166, which number has now been increased by the zeal and industry of North American botanists to 2357, as is shown by a hasty count of the distinct and truly indigenous species described in the present volume.

The various Analytical keys have been prepared anew, and evidently with the greatest carefulness, the distinctions being based upon the important characters of the plants, rather than upon their trivial peculiarities, so that to a student who has thoroughly studied Physiological Botany, as taught for instance in Gray's Lessons, these Analytical keys will not only open an easy way to find the name of an unknown plant, but will also reveal much of the true relations of the plant to the whole Vegetable Kingdom.

In certain orders and genera the author has had the aid of collaborators who have devoted special attention to their several departments, among whom Dr. Engelmann takes the lead: all such assistance is amply acknowledged in the proper place.

As to thorough scientific arrangement, correct nomenclature, and accuracy and clearness of the definitions, this Flora is almost or quite unrivalled, there being no American, and few European works of the kind, which could bear comparison with it; and it will be well for the cause of American learning if this Flora, suited alike to the needs of

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accomplished botanists and unpracticed students, shall displace works which are wholly rejected by the former, and are used by the latter only to their own injury and confusion. D. C. E.

IV. ASTRONOMY.

1. *Recent Observations and Remarks of Hofrath Schwabe regarding Sun-spots and other Solar Phenomena.* Communicated by W. De la Rue, B. Stewart, and B. Loewy.—About two months ago Hofrath Schwabe called our attention to certain phenomena on the surface of the Sun, which he had noticed since last December, and which he recollected to have occurred before, but only at the time of a minimum in the number of Sun-spots. The phenomena are:—1st. *A total absence of faculæ or faculous matter.* 2nd. *Absence of the usually observed scars, pores, and similar appearances.* 3rd. *An equal brightness of the whole surface, the limb being as luminous as the center.*

Hofrath Schwabe desired us to go over his observations, which are at present at Kew Observatory, to extract similar facts formerly noticed, and to inform him whether some of these phenomena had also been observed in this country.

The observations were carefully scanned; and it was noticed that the phenomena occur only in years of minimum spot-frequency. The extracts, which we append, and which might have been multiplied, are quite sufficient to show the regularity of their recurrence, and also that the year 1833 was particularly characterized by the frequency of observations of them.

We also applied to the Rev. F. Howlett, whose well-known exquisite delineations of Sun-spots and faculæ gave us the best promise of learning something more relating to delicate changes on the surface of the Sun; but unfortunately Mr. Howlett's impaired health has obliged him to withdraw almost wholly from his usual application to Sun observations during the period in question. He however states in his answer, that "he had certainly noticed how uniformly bright the Sun's surface has been of late, in connection with an almost total absence of faculæ."

We think it right to state (without expressing our own opinion in the matter) that Hofrath Schwabe thinks he has noticed a connexion between Sun-spots and meteoric showers. He says in his last letter, "The minimum of spot-frequency coincides remarkably with the recurrence of meteoric showers, the period of rotation of which, viz., 33·2 years, agrees with a larger period of the sun-spots. In 1833 there was an extreme scarcity of spots (only 33 very small groups being observed), and in 1866–67, after 33 years the phenomenon repeats itself. From the 1st January until to-day, June 8th, I have only observed 6 small groups, and out of 133 days of observation, there were 100 without spots. In the year 1848, which is the middle of the 33·2 years period, there was a maximum of spots. If the 33 years' period should be established by future observations, then a maximum of meteoric showers would always occur after three years of the usual Sun-spot periods. Whether this periodicity existed before, I cannot decide, but there appears to have been a minimum of Sun-spots in 1798·5, and a maximum in 1816·8."

We are at present engaged in determining a curve of spot-frequency during the last forty years, founded, not on the *number of observed groups,*

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but on the *area of spotted surface*, as observed by Hofrath Schwabe; and we hope that by this means the periodicity will be represented with greater precision than before, and also that more light will be then thrown on the whole subject; but in the meantime we would call the attention of all observers to the fact, that in the present state of our inquiries into the physical nature of the Sun and into the connexion of cosmical phenomena, even the most delicate changes observed deserve great attention, and that nothing should be overlooked by those who take an active interest in this problem.—*Not. Roy. Astron. Soc.*, xxvii, 286.

2. *On a Meteor of July 18th*, 1867; by DANIEL KIRKWOOD, (Editorial correspondence dated Canonsburg, Pa., August 5th, 1867).—Mr. J. K. Larimore, A. B., has furnished me the following account of a meteor seen by himself, at Salem, Westmoreland County, Pennsylvania, on the 18th of July, 1867.

The time of observation was about $7^h\ 30^m$ P. M.—almost exactly at sunset. The meteor seemed to have originated in the S.E. quarter of the heavens, and it disappeared in the N.E. When first seen its elevation was about 40°, and it continued visible from four to five seconds. Its apparent diameter was estimated at one-fourth that of the moon, and it had a train three or four degrees in length.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Researches on Gun-cotton.—Second memoir. On the Stability of Gun-cotton;* by F. A. ABEL, F.R.S., V.P.C.S. (From the Phil. Mag., IV, xxxiii, 545, July, 1867, Supplement.)—The results of the many observations which had been instituted prior to 1860 upon the behavior of gun-cotton when exposed to diffused or strong daylight, or to heat, although they agree generally with those of the most recent investigations on the subject, as far as relates to the nature of the products obtained at different stages of its decomposition, cannot be regarded as having a direct bearing upon the question of the stability of gun-cotton produced by strictly pursuing the system of manufacture prescribed by von Lenk, inasmuch as it has been shown that the products formerly experimented upon by different chemists varied very considerably in composition.

The investigations recently published by Pélouze and Maury* on the composition of gun-cotton, and the influence exerted by light and heat upon its stability, are described as having been conducted with gun-cotton prepared according to von Lenk's system. The general conclusion arrived at by those chemists with reference to the latter branch of the subject was to the effect that the material is susceptible of spontaneous decomposition, under conditions which may possibly be fulfilled in its storage and application to technical and warlike purposes; and the inference is drawn, partly from the results of earlier investigators, and partly from the exceptional behavior of one or two specimens, that gun-cotton is liable to explode spontaneously at very low temperatures when stored in considerable quantities.

It has been shown, in the memoir on the Manufacture and Composition of Gun-cotton, published last year,† that modifications in the pro-

* Comptes Rendus.

† Trans. Royal Society. For abstract see Phil. Mag., IV, xxxii, 145.

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cesses of conversion and purification, which appear at first sight of very trifling nature, exert most important influences upon the composition and purity of the product. Gun-cotton of quite exceptional character has been discovered, in several instances, among samples received from Hirtenberg and among the first supplies obtained from Stowmarket; other exceptional products have also been produced by purposely modifying, in several ways, the system of manufacture as pursued at Waltham Abbey. The very considerable difference exhibited between some of these and the ordinary products in their behavior under equal conditions of exposure to heat and light, affords good grounds for the belief that the attainment of certain exceptional results, upon which the conclusions of Pélouze and Maury's report condemnatory of gun-cotton have been principally founded, are to be ascribed to such variations in the nature of the material operated upon.

Very numerous and extensive experiments and observations have been carried on during the last four years at Woolwich, both with small and large quantities of gun-cotton, for the purpose of completely investigating the conditions by which the stability of this substance, when under the influence of light and heat, may be modified, and with the view of ascertaining whether results recently arrived at in France apply to gun-cotton as manufactured in this country.

The principal points which have been established by the results arrived at in these investigations may be summed up as follows:—

(1.) Gun-cotton produced from properly purified cotton, according to the directions given by von Lenk, may be exposed to diffused daylight, either in the open air or in closed vessels, for very long periods without undergoing any change. The preservation of the material for 3½ years under those conditions has been perfect.

(2.) Long-continued exposure of the substance in a condition of ordinary dryness to strong daylight and sunlight produces a very gradual change in gun-cotton of the description defined above; and therefore the statements which have been published regarding the very rapid decomposition of gun-cotton when exposed to the sunlight do not apply to the nearly pure trinitrocellulose obtained by strictly following the system of manufacture now adopted.

(3.) If gun-cotton in closed vessels is left for protracted periods exposed to strong daylight or sunlight in a damp or moist condition, it is affected to a somewhat greater extent; but even under these circumstances the change produced in the gun-cotton by several months' exposure is of a very trifling nature.

(4.) Gun-cotton which is exposed to sunlight until a faint acid reaction has become developed, and is then immediately afterward packed into boxes which are tightly closed, does not undergo any change during subsequent storage for long periods. (The present experience on this head extends over 3½ years.)

(5.) Gun-cotton prepared and purified according to the prescribed system, and stored in the ordinary dry condition, does not furnish any indication of alteration, beyond the development, shortly after it is first packed, of a slight peculiar odor and the power of gradually imparting to litmus, when packed with it, a pinkish tinge.

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(6.) The influence exercised upon the stability of gun-cotton of average quality, as obtained by strict adherence to von Lenk's system of manufacture, by prolonged exposure to temperatures considerably exceeding those which are experienced in tropical climates, is very trifling in comparison with the results recently published by Continental experimenters relating to the effects of heat upon gun-cotton; and it may be so perfectly counteracted by very simple means, which in no way interfere with the essential qualities of the material, that the storage and transport of gun-cotton presents no greater danger, and is, under some circumstances, attended with much less risk of accident than is the case with gunpowder.

(7.) Perfectly pure gun-cotton, or trinitrocellulose, resists to a remarkable extent the destructive effects of prolonged exposure to temperatures even approaching 100° C.; and the lower nitro-products of cellulose (soluble gun-cotton) are at any rate not more prone to alteration when pure. The incomplete conversion of cotton into the most explosive products does, therefore, not of necessity result in the production of a less perfectly permanent compound than that obtained by the most perfect action of the acid mixture.

(8.) But all ordinary products of manufacture contain small proportions of organic (nitrogenized) impurities of comparatively unstable properties which have been formed by the action of nitric acid upon foreign matters retained by the cotton fiber, and which are not completely separated by the ordinary, or even a more searching process of purification.

It is the presence of this class of impurity in gun-cotton which first gives rise to the development of free acid when the substance is exposed to the action of heat; and it is the acid thus generated which eventually exerts a destructive action upon the cellulose-products, and thus establishes decomposition which heat materially accelerates. If this small quantity of acid developed from the impurity in question be neutralized as it becomes nascent, no injurious action upon the gun-cotton results, and a great promoting cause of the decomposition of gun-cotton by heat is removed. This result is readily obtained by uniformly distributing through gun-cotton a small proportion of a carbonate,—the sodic carbonate, applied in the form of solution, being best adapted to this purpose.

(9.) The introduction into the finished gun-cotton of one per cent of sodic carbonate affords to the material the power of resisting any serious change, even when exposed to such elevated temperatures as would induce some decomposition in the perfectly pure cellulose-products. That proportion affords, therefore, security to gun-cotton against any destructive effects of the highest temperatures to which it is likely to be exposed even under very exceptional climatic conditions. The only influences which the addition of that amount of carbonate to gun-cotton might exert upon its properties as an explosive would consist in a trifling addition to the small amount of smoke attending its combustion, and in a slight retardation of its explosion, neither of which could be regarded as results detrimental to the probable value of the material.

(10.) Water acts as a most perfect protection to gun-cotton (except when it is exposed for long periods to sunlight), even under extremely severe conditions of exposure to heat. An atmosphere saturated with

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aqueous vapor suffices to protect it from change at elevated temperatures; and wet or damp gun-cotton may be exposed for long periods in confined spaces to 100° C. without sustaining any change.

Actual immersion in water is not necessary for the most perfect preservation of gun-cotton; the material, if only damp to the touch, sustains not the smallest change, even if closely packed in large quantities. The organic impurities which doubtless give rise to the very slight development of acid observed when gun-cotton is closely packed in the dry condition, appear to be equally protected by the water; for damp or wet gun-cotton, which has been preserved for three years, has not exhibited the faintest acidity. If as much water as possible be expelled from wet gun-cotton by the centrifugal extractor, it is obtained in a condition in which, though only damp to the touch, it is perfectly non-explosive; the water thus left in the material is sufficient to act as a perfect protection, and consequently also to guard against all risk of accident. It is therefore in this condition that all reserved stores of the substance should be preserved, or that it should be transported in large quantities to very distant places. If the proper proportion of sodic carbonate be dissolved in the water with which the gun-cotton is originally saturated for the purpose of obtaining it in this non-explosive form, the material, whenever it is dried for conversion into cartridges, or employment in other ways, will contain the alkaline matter required for its safe storage and use in the dry condition in all climates.

2. *Scientific party for Sitka.*—A scientific party left San Francisco July 21st on the steam cutter *Lincoln* for Alaska. This party has been organized under the direction of Prof. Peirce, Superintendent of the U. S. Coast Survey, and is conducted by George Davidson, Assistant U. S. Coast Survey, as chief. With him are associated A. T. Mosman, Astronomer; Geo. Farquhar, hydrographer; with whom is associated I. Forney, as aid;—Hamel, engineer; Dr. Albert Kellogg, botanist; W. G. W. Harford, Conchologist; T. A. Blake, Geologist, and John Tidal, observer. The first business will be a geographical reconnoissance of the Coast.—*San Francisco Bulletin.*

3. *American Association for the Advancement of Science.*—The meeting of the Association at Burlington is just now closing as we put the last pages of this number to the press. We have to defer a notice of the proceedings to our November number.

OBITUARY.

Jeremiah Day.—Jeremiah Day, the venerable ex-President of Yale College, died at his residence in this city, on Thursday evening, August 22.

President Day had reached, on the 3d of the present month, the age of ninety-four years. His death will naturally occasion little surprise; yet the announcement of it will affect the hearts of thousands of pupils and friends who have long looked up to him with profound veneration and esteem.

He was born in New Preston, Conn., August 3, 1773. He first entered Yale College in 1789, seventy-eight years ago. Owing to ill health, he was absent from College for a considerable time, and did not graduate until 1795, the year when Dr. Dwight became president. The first official act of this eminent man was to preside at the Commencement at

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which the class of which President Day was a member was graduated. Mr. Day succeeded Dr. Dwight as teacher of the school which the latter had conducted at Greenfield, and remained there until his election as tutor in Williams College. In 1798 he became tutor at Yale, and while holding this office pursued theological studies and preached as a candidate for the ministry. In 1801 he was elected to the professorship of Mathematics and Natural Philosophy. His health at this period was feeble, and neither he nor his friends anticipated for him a long continuance of life. He was able, however, to enter on the duties of his new station in 1803, which he continued to discharge until 1817, when, on the decease of Dr. Dwight he was chosen president, and continued in this office until his resignation in 1846. He fulfilled the duties of the presidency with distinguished success and with the entire approbation of the college and of the public. He remained a member of the corporation until the last commencement, when, in consequence of his "diminishing powers of life,"—to quote his own apt phraseology—he severed this last link of official connection with the college which he had served so long and faithfully. President Day was the author of a series of mathematical text-books which have passed through numerous editions. He also published two metaphysical treatises on the subject of the Will, besides various papers in the New Englander and other periodicals. In 1810 he published a brief paper, in the Memoirs of the Connecticut Academy of Sciences, on the origin of meteorites, called out by the recent fall (in 1807) of the meteorite of Weston, in which he took the ground, that they were cometary bodies of the solar system.

President Day possessed a strong understanding, and was more remarkable for the balance and symmetry of his powers than for the extraordinary development of any one of them. He was an exact thinker and a clear reasoner. His great moral and religious excellence has been universally recognized from his youth up. None who knew President Day will feel that there is any exaggeration in applying to him the sentence: "Mark the perfect man and behold the upright, for the end of that man is peace."

He was the last survivor of the colleagues whom President Dwight selected and drew around him, and whose united labors first gave celebrity to Yale College. Kingsley, Silliman, and now Day, the oldest of the three, are gone; but they deserve to be perpetually honored by all who feel an interest in the institution to which their labors were devoted.

F.

E. J. Pickett.—Edwin Judson Pickett was born near Rochester, N. Y., in 1830, and from early childhood that city was his home. Graduating from the University of Rochester in 1856, he afterward devoted his life to teaching and to the study of the natural sciences, geology finally becoming his favorite pursuit. In 1861, he received an appointment in the Institute at Mexico, N. Y., and in 1864, was appointed to the Professorship of Natural Science in the People's College at Havana, N. Y. After the failure of that institution, he took charge of a flourishing Collegiate Institute at Attica, Ind., and continued in the work until consumption, which had long before undermined his health, compelled him to seek his home and there await its lingering termination. He died on the 13th of October, 1866.

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Mr. Pickett was of an exceedingly modest and retiring disposition, and did not seek society; but none who met him could fail to love him. An enthusiast in science, an indefatigable worker in whatever he put his hand to, and also an earnest Christian, his loss is a great one. With so few devotees, and so much work to be done, science can ill afford to spare one such. B.

FARADAY.—The telegraph brings the announcement that the eminent philosopher, Faraday, died on the 27th of August, in his 73d year.

VI. MISCELLANEOUS BIBLIOGRAPHY.

1. *Annals of the Astronomical Observatory of Harvard College.* Vol. II, Part II, and Vol. V. Cambridge, 1867. 4to, pp. 263, 215.—Part I of vol. II (Observations on Saturn) was published in 1857. Part II, just issued, contains a Zone Catalogue of 4484 stars situated between 0° 20′ and 0° 40′ north declination, observed during the years 1854–55, with the Cambridge equatorial. A similar catalogue of 550 stars (between 0° 0′ and 0° 20′ N. dec.) constitutes Part II of vol. i, where may be found the introductory matter pertaining to both series of zone observations. Two other like series still remain unpublished. These catalogues extend to stars of the 13th magnitude, and afford ample evidence of the ability and zeal with which the two Bonds, father and son, were accustomed to employ the great telescope which constitutes the principal instrument of the Cambridge Observatory.

The other volume just issued, the fifth of the series, gives the results of the latest labors of Prof. G. P. Bond—his elaborate observations on the great nebula in Orion. These observations were undertaken in 1857, but being interrupted, in 1858, by the work due to the great comet of that year, and by other causes, were resumed after the publication of the volume on the comet, and prosecuted as the failing strength of Mr. Bond would permit, nearly to the time of his death, in 1865. The splendid engraving of the nebula, which accompanies this volume, was executed under his eye, and the impressions taken in 1864. The observations were also reduced, for the most part, before the death of Mr. Bond, and the materials left in such a state of forwardness that, with the careful editorship of Prof. Safford, so long associated with Prof. Bond in the observatory, the work is now presented to astronomers, if not in as complete a form as it would have been had the life of the author been longer spared, yet in such a shape as to render it a noble contribution to astronomical science, and greatly enhance the already high reputation of its lamented author.

The volume is in the style of that on Donati's Comet, and the engravings are by the same artist. Besides the engraving, already referred to, from the drawing of Prof. G. P. Bond, it contains another representing the nebula as seen by Prof. W. C. Bond, with the same telescope, in 1848, and also two charts of the stars in and near the nebula, as laid down by the same author. The principal work of Prof. G. P. Bond consisted in determining, by differential observations, the positions with reference to θ Orionis of all stars visible with the Cambridge equatorial within an area extending 1° 30′ on each side of this star in declination,

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and $2^m\ 15^s$ each way in right ascension. This area of 3·36 square degrees embraces 1000 stars, or 298 to a square degree.

The different sections of the volume exhibit in detail the observations for the positions of these stars, a discussion of the observations by the Method of Least Squares, the resulting catalogue of positions referred to θ Orionis, a comparison of this catalogue with others, particularly Otto Struve's, Sir J. Herschel's, and Liapunoff's, the notes of Prof. Bond accompanying the observations, his original observations on the physical characteristics of the nebula, and a reprint, from the Proceedings of the American Academy, of his paper on its spirality, together with two appendices, one relating to the observations of the elder Bond, and the other to the errors of the equatorial as affecting the micrometrical measurements. With the discussions and explanatory notes of the editor, this volume presents materials of inestimable value to future observers of this nebula, and will contribute largely toward enabling them to settle the various questions relating to changes of form and brightness in this object, and to the variability of the stars in and near it. The latter question is discussed to some extent in the present volume.

Astronomers will await with interest the results of the observations on this and other nebulæ, which it is understood Prof. Safford is engaged in making with the great 18½ inch refractor of the Dearborn Observatory at Chicago, of which institution he is the Director.

His work of editing the volume before us was completed while he was acting director of the Cambridge Observatory, in the interval between the death of Prof. Bond and the accession of the present incumbent, Prof. Winlock.

2. *The Chemical News, and Journal of Physical Science.* American edition. New York, W. A. Townsend & Adams. July and August, 1867. pp. 48 and 60.—The English edition of the Chemical News is well known and justly appreciated in this country. When the republication of it in New York was announced, at a moderate subscription price, we felt that the publishers were doing the cause of science a real service. We have now before us the July and the August numbers. They follow closely their English original, with the important exception that the reprint, instead of appearing weekly, is issued monthly, having four of the English weekly numbers in one. Moreover, instead of giving the numbers consecutively and separately, the articles from each have been rearranged under their respective heads. The July number contains Nos. 387, 388, 389, 390, issued in London May 3, 10, 17 and 24; the August number, Nos. 391, 392, 393, 394, 395, issued May 31, June 7, 14, 21, 28; making a difference in time of two months. Again the parts issued are announced as Vol. I, Nos. 1 and 2, with no mention that they are really a portion of Volume XV, beginning near its middle. It is therefore quite impossible to tell in which of the weekly numbers, any given article was printed; and it is also impossible to find an article in either edition, by a single reference to the other. A reprint should be in every case an exact fac-simile of the original. The publishers state in a letter to the Editors of this Journal, that the preservation of the English dates and paging will "doubtless be hereafter introduced," and we hope that for the benefit of science it may be at once done.

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3. *A Treatise on Astronomy, Spherical and Physical*, with Astronomical Problems, and Solar, Lunar, and other Astronomical tables, for the use of Colleges and Scientific Schools; by WILLIAM A. NORTON, M.A., Prof. of Civil Egineering in Yale College. Fourth edit., revised, remodelled and enlarged. 444 pp. text, with 114 pp. additional of tables, and numerous wood-cuts. New York, 1867 (John Wiley & Son).—Professor Norton, as his title page and more fully his preface states, has entirely remodelled his Astronomy, and adapted it thereby to the present state of the science. The chapters on astronomical instruments, comets, the physical constitution of the sun, zodiacal light, and others have been rewritten, and the text generally has been enlarged by the addition of more extended descriptions of astronomical facts, and an account of recent deductions with regard to the physical constitution of the heavenly bodies, and brief expositions of physical theories bearing on the subject, while the more difficult investigations of astronomical formulas occurring in the text of the former edition, have been transferred to the appendix. The work is an excellent college text book, and is rendered especially convenient for the practical astronomer by the mathematical tables, 96 in number, with which it closes.

4. *Elements of Chemistry, Theoretical and Practical;* by WILLIAM ALLEN MILLER, M.D., LL.D., Treas. and V. President Roy. Soc., V. P. Chem. Soc., etc. Part II, *Inorganic Chemistry.* From the 3d London edition. 806 pp., 8vo, with numerous wood-cuts. New York, (John Wiley & Son).—Messrs. Wiley & Son are doing good service to American science in the republication of the excellent work on Chemistry by Prof. Miller. There is no better one in the English language. Professor Miller has combined in his treatise the practical with the theoretical in a way that renders it useful and popular beyond the limits of the ordinary chemical class and lecture room. The volume is handsomely printed, and well illustrated.

5. *A Popular Treatise on Gems in reference to their scientific value, a guide for the teacher of Natural Sciences, the Lapidary, Jeweller, and Amateur, &c.;* by Dr. L. FEUCHTWANGER. 3d edit., 504 pp., 12mo. New York, 1867.—Dr. Feuchtwanger's treatise on gems is a popular work, containing much information of interest to science, the jeweller's art, and the wearers of jewels. It is illustrated by numerous plates, some of them colored, and very naturally so.

6. *Annual of the National Academy of Sciences for* 1866. 154 pp. 12mo.—This volume contains an excellent biographical notice of James Melville Gillis of the Washington Observatory, by B. A. Gould; a second of Benjamin Silliman, by A. Caswell; and a third, not unexceptionable, of Edward Hitchcock, by J. P. Lesley.

7. *Memoirs of the Boston Society of Natural History*, Volume I, Part II.—The following are the contents of this volume.—Page 131, Osteology of the *Colymbus torquatus*, with notes on its myology, with a plate; E. COUES.—p. 173, Zoological relations of the first-discovered traces of Fossil Neuropterous Insects in North America, with remarks on the difference of structure in the wings of living Neuroptera, with a plate; S. H. SCUDDER.—p. 193, On the parallelism between the different stages of life in the individual and those in the entire group of the Molluscous

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order Tetrabranchiata; A. HYATT.—p. 210, On the glacial phenomena of Labrador and Maine, with a view of the recent invertebrate Fauna of Labrador; A. S. PACKARD.

8. *Transactions of the American Entomological Society*, Vol. I, No. 1, 120 pp., 8vo, with two colored plates. Philadelphia.—This first number contains (1) Descriptions of American Lepidoptera No. 1, by A. R. Grote and C. T. Robinson; (2) Catalogue of the described Tenthadinidæ and Uroceridæ of N. America, by Edward Norton; (3) Notes on the Pompilidæ of N. America, with descriptions of New Species, by E. T. Cresson.

PROCEEDINGS AMER. ACAD. ARTS AND SCI., Boston, 1866, Vol. VII.—p. 99, On an improved apparatus for the determination of vapor densities; *C. M. Warren.*—p. 103, Biographical notice of Jared Sparks.—p. 135, Comparative qualities of shot and guns; *D. Treadwell.*—p. 143, Enumeration of Hawaiian Plants; *H. Mann.*

ANNALS LYC. NAT. HIST. OF NEW YORK, Oct. Dec. 1866, Vol. VIII, Nos. 13, 14.—p. 351, Lepidopterological Contributions; *A. R. Grote & C. T. Robinson.*—p. 387, Notes on the nat. hist. of the scorpion; *R. Hill.*—p. 394, On some species of W. I. maritime shells in the cabinet of Amherst College; *H. Krebs.*—p. 399, On the classification of the Appredorus gibbosus of LeSueur, and Scolopsis sajanus of J. Gilliams; *T. A. Telkampf.*—p. 400, Descriptions of six new species of birds of the families Hirundinidæ, Formicaridæ, Tyrannidæ and Trochilidæ; *G. N. Lawrence.*

PROCEEDINGS ESSEX INSTITUTE, Vol. V, June, 1867.—p. 57, Fermeyer's Researches, etc., on Silk from Spiders; translated by *B. G. Wilder.*—p. 79, List of birds observed near Hamilton, C. W.—Part II of Naturalist's Directory, North America and the West Indies; Botany.

PROCEEDINGS ACAD. NAT. SCI. OF PHILADELPHIA, 1867, No. 2.—Page 33, Structure of Lopezia; *T. Meehan.*—p. 34, Mammalogical notices; *J. H. Slack.*—p. 39, On Euclastes, a genus of extinct Cheloniidæ; *E. D. Cope.*—p. 42, Diœcious forms of Vitis vinifera; *T. Meehan.*—New species of Texan Myriapoda; *H. C. Wood.*—p. 44, Two new minerals from Chester Co., Pa.; *I. Lea.*—p. 45, A third study of the Icteridæ; *J. Cassin.*—p. 75, Notes of Micropus leucopterus of Say ("The Chinch Bug"), with an account of the great epidemic disease of 1865 among Insects; *H. Shimer.*

PROCEEDINGS BOSTON SOC. NAT. HIST., Vol. XI.—P. 83, On a sculptured stone from L. Utopia, N. Brunswick; *E. Bicknell.*—p. 89, List of the Birds of St.Domingo, with descriptions of some new species or varieties; *H. Bryant.*—p. 117, On some Fossil insects from the Tertiary of Green river, Colorado; *S. H. Scudder.*—p. 118, On monstrosities observed in wings of Lepidopterous Insects, and how they may be produced; *L. Trouvelot.*—p. 120, On a Fungoid parasite or Caterpillar Fungus, from the Philippine Islands; *S. Kneeland.*—p. 125, Habits of Migratory fishes; *T. Lyman.*

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF PHILADELPHIA, Vol. VI, 1866-7.—Page 1, Lepidopterological notes, No. 2; *Grote & Robinson.*—pp. 31, 189, On the Pselaphidæ; *E. Brendel.*—pp. 39, 353, Fossorial Hymenoptera of N. America; *A. S. Packard.*—p. 106, Prof. Dana and his Entomological speculations; *B. D. Walsh.*—p. 122, Coloradian Butterflies; *T. Reakirt.*—pp. 152, 335, New N. A. Formicidæ; *S. B. Buckley.*—pp. 173, 287, On the Zygænidæ of Cuba; *A. R. Grote.*—p. 195, On certain N. A. species of Satyrus; *W. H. Edwards.*—p. 200, On certain Diurnal Lepidoptera of the U. S. and British Amer., No. 5; *W. H. Edwards.*—New species of Chrysophanus; *H. Behr.*—p. 209, On certain Entomological speculations—a Review; *A. S. Packard.*—p. 219, Two new N. A. Cecidomyiæ; *Osten Sacken.*—p. 221, Notes on Thyridopteryx ephemeræformis; *B. Clemens.*—p. 223, On the insects of the Galls of certain Willows; *B. D. Walsh.*—pp. 289, 296, Habits of a few Californian Coleoptera; on Usechus lacerta; on Rhadodera tuberculata; and observations on Phodaga alticeps; *G. H. Horn.*—p. 351, New species of Trigonalys; *E. T. Cresson.*—p. 445, Description of new species of N. A. Brachycerous Diptera; *A. R. Grote.*

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THE

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[SECOND SERIES.]

ART. XXXII.—*Address of* GEORGE BENTHAM, Esq., F.R.S., *President, read at the Anniversary meeting of the Linnean Society on Friday, May* 24, 1867.

IN my address of 1865 I attempted a general sketch of the more important Transactions of Scientific Societies or Scientific Journals in which papers on Zoology or Botany are being published, passing over, however, for want of time and space, those in the English language, beyond a mere mention of their titles. I have been since requested to resume the subject, in so far as the North American publications are concerned; and I the more readily avail myself of this opportunity of doing so, as there are some points in regard to their proceedings on which it may be useful to institute a comparison with those of European institutions. In this review, however, I meet with one difficulty; I have never been in America, and have no personal experience of the working of their institutions, as I had of so many of the European ones, and am obliged to collect the data from their published reports. I trust, therefore, my friends across the Atlantic will excuse any errors I may have committed through inadvertency, or any material points I may have passed over from ignorance.

Our American colonists before the outbreak of the war of Independence had already begun to turn their attention to the cultivation of science, and especially to the investigation of the rich and varied fauna and flora of their territory, and several Societies or Academies for the promotion of these studies and the publication of transactions on the model of European ones were

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founded, either immediately before the great contest, or during the first years of the settlement of the States.

The American Philosophical Society, held at Philadelphia for promoting useful knowledge, was established in 1769, and soon commenced their 4to Transactions, the 1st volume having apparently been published in 1771, although, for some reason unknown to me, it bears the date of 1789. It contains nothing bearing upon Biology, except a few practical agricultural or horticultural papers; and the publication was interrupted during the years of trouble, until the Society was reorganized in 1780. A second volume is dated 1786, and four more complete the first series, which was closed in 1804 with the sixth volume. It contains, amongst a great variety of subjects, a few, mostly short, zoological papers chiefly in Ichthyology, Erpetology and Entomology by B. H. Latrobe, B. S. Barton, and Dr. Williamson, two small contributions to American Botany sent from Europe by Thunberg and Palisot de Beauvois, and an Index Floræ Lancastriensis by Muhlenberg. The labors of the Society appear then to have been suspended for nearly fourteen years; for it is only in 1818 that we find a new series commenced, and continued more or less steadily to the present time, the last received being two parts of the 13th vol. dated 1865. All are in 4to, but with gradually improving typography, paper, and illustrations, and a somewhat enlarged size adopted with the 10th vol., dated 1853. The series comprises all sciences among the subjects treated of; but a large proportion of the papers are devoted to the investigation of the Natural History (including Biology, Geology, Ethnology, and Linguistics) of the United States. J. Lea's malacological papers are perhaps the most extensive, going through nine out of the thirteen volumes. Entomology is next in order, in the earlier volumes by T. Say and N. M. Hentz, in the latter ones by J. L. Leconte, with a paper on Coleoptera by S. S. Haldeman, and another on Myriapoda by H. C. Wood, Jr. In other branches of Zoology, E. Hallowell on the reptiles of Cuba and the United States, S. F. Baird's Zoology of the Upper Missouri, and J. Leidy's papers, chiefly physiological or paleontological, are the most important, the contributions to Mammology, Ornithology and Ichthyology being few and short. In Botany there are several of Nuttall's descriptions of plants collected during his various expeditions, an enumeration of no less than 3,098 North American Fungi by L. D. de Schweinitz in the 4th vol., G. Engelmann's Botany of the Upper Missouri, E. Durand's Botany of the Great Salt Lake, and a few short contributions of minor importance. In 1838 the Society also commenced publishing their Proceedings in 8vo, after the model of European Societies. Of these we have 9 vols., from 1838 to 1864, including several papers of considerable length, occasionally illustrated by plates,

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but chiefly on Physical Sciences, Geology, or Paleontology. In Biology there is nothing beyond a few abstracts for the purpose securing priority of names, or short communications of very little importance.

The diminished proportion of Natural History papers in the later volumes of the Philosophical Society's publications is fully accounted for by the activity of another Society in the same city devoted exclusively to Natural Science. This Academy of Natural Sciences of Philadelphia was established early in 1817, and immediately began the publication of the 'Journal of the Academy of Natural Sciences in Philadelphia,' in 8vo, issued in parts at irregular intervals, with a few plates. The first series of 8 vols., from 1817 to 1842, was chiefly a receptacle for short papers in almost all branches of Zoology, as well as in Geology and Mineralogy, with a very few botanical contributions by T. Nuttall, G. Elliot, L. D. de Schweinitz, and S. W. Conrad, all of little importance.

In 1841 the Academy commenced publishing their Proceedings in 8vo, at short intervals, forming 8 vols., for the years 1841 to 1856 inclusive, and since then one volume (not numbered) for each year, from 1857 to 1865, the last received. They contain short communications, abstracts of the longer papers intended for the Journal, and some entire papers of greater length, with a few illustrations, woodcuts, or lithographs; and in some of the earlier volumes J. Cassin's Ornithological papers are accompanied by colored plates. In these 17 vols., will be found a valuable record of observations and numerous descriptions of North American species in almost every department of Zoology.

In 1847 the Academy resumed the publication of the more extended papers in a work issued as a new series of the Journal, but in a large 4to form, with plates executed in a superior manner, many of the zoological ones colored; corresponding, in short to the Transactions of other Societies. The five volumes issued up to 1863, besides a few papers on exotic animals or on general subjects, contain important and valuable contributions to the Zoology of the United States, amongst which may be particularly mentioned the papers in Ornithology by J. Cassin, Erpetology by E. Hallowell, Malacology and Conchyliology by I. Lea and T. A. Conrad, and Entomology by J. L. Leconte and R. Clemens, besides shorter communications in various branches of Zoology by naturalists of note. Botany is limited to Nuttall's account of Gambel's plants, a paper by M. J. Berkeley and M. A. Curtis on Fungi, and E. Durand's accounts of Heermann's and of Pratten's collections.

In this Journal I observe that the date of issue of the author's copies of each separate paper is given in a note to the table of contents. This is no doubt with a view to fixing a

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date on which the priority of discovery or of names is to be established. It has been universally acknowledged that priority depends upon the date of publication; but it has been a much debated question what amounts to a publication so as to fix that date. Is it to be the time when a paper is read, or when it has gone through the press so as to prevent any further alterations on the part of the author, or when it is actually given out for sale, or simply the date it bears on the title page? I believe that at the Royal Society the date of reading a paper is considered as a sufficient publication to establish rights of priority in a discovery or invention, and, in a legal point of view, with reference, for instance, to the law of patents, it seems reasonable that it should be so; for it is not fair that an inventor should obtain the sole right to his invention when the same or a similar one had been produced at the same time or before him, although not in a manner in which he could have cognizance of it; and for establishing such a fact the reading of a paper may be sufficient evidence. Both inventors can then enjoy the credit and benefit of their invention, but neither of them to the exclusion of the other. This also supposes that no alteration is allowed in a paper after it has once been read, unless it be clearly designated by brackets or otherwise, as I believe to be the practice of the Royal Society. In Biology, however, the case is different, the object is not only to establish that priority or rather independence of observation or discovery which can be enjoyed equally by two or more naturalists, but also the priority of name, which is a more complicated question, for an animal or plant cannot retain two names; when, therefore, it is found that it has been differently named by two or more naturalists it is necessary to decide which one should be exclusively adopted. In principle, it is the universal rule among botanists, and, I believe, a general one among zoologists, that, supposing there is no absolute objection to either name, that one is to be retained which was first fixed by actual publication,—its insertion in a work on sale or in general distribution, accompanied by diagnostic characters or other indications intended to fix its identity. The reading a paper at a meeting of a Society is not a publication for this purpose, only because it does not give fixity; the author himself does not feel bound by it and (possibly from the discussion evoked or observations made at the reading) may alter his names before or during the printing. A purely technical paper is, indeed, not even actually read, and often laid before the meeting in an unfinished state, the substance of it being verbally explained. The other objection, as to the impossibility of a naturalist not actually present having cognizance of a paper read at a meeting until it is in print is only one of degree, and may even tell the other way, for he

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may see it in print long before he can possibly procure a rival one from the antipodes although previously published.

It being admitted, then, that the date of a name is that of its actual publication, there still remains sometimes the practical difficulty of determining when that publication took place. *Primâ facie* evidence is the date given on the title-page of the work, but that is occasionally unfairly erroneous. The whole of Rees's Cyclopedia, in which much Zoological and Botanical matter is original, bears on the title-pages the date of 1819, when some of the volumes were published nearly twenty years earlier. Presl's Botanische Bemerkungen, with innumerable new or altered names of plants, is dated the second year before it was on sale. The Annales des Sciences Naturelles are notoriously antedated by several months. Grisebach's Monograph of Gentianeæ, dated 1839, was received in this country the previous November. The first parts of Ecklon and Zeyher's Enumeratio, and of Ernst Meyer's Commentatoines on South African Plants, each describing as new or renaming two or three hundred species of Leguminosæ, many of them identical in the two works, appeared almost simultaneously; but Ecklon and Zeyher's was actually published, as dated on the cover, in January 1836, whilst E. Meyer's, which was not issued to the public till the 14th of February 1836, has the ostensible date of December 1835. In order to do justice to the authors under similar circumstances extrinsic evidence has been generally admitted to correct the dates apparent on the title. In the case of Transactions of Scientific Societies this extrinsic evidence, often difficult to establish, is particularly required. There are generally two dates given, that of the reading, affixed to each paper, and that of the completion of the volume, given on the title-page; the former would be unfair to the rival observer, who might be superseded by alterations made after the reading of the paper, the latter equally unfair to the author, whose memoir, if in the first part of the volume, may have been in the hands of the public for years before the apparent date. In some Transactions this is remedied by printing the date of publication of each separate part; but even that is not always enough, for author's separate copies have sometimes been generally circulated, and even on sale, a considerable time before the complete part to which they belong. It is for the purpose of fixing this date (which ought surely to be admitted as a sufficient publication) that in the Philadelphia Journal the date of issue of the author's copies is, as above mentioned, noted in the table of contents. We have been considering whether a similar plan might not be adopted for our own Transactions, but it has been thought unnecessary to make the alteration, for the cases are very few where the author's copies are ready for delivery much before the

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part in which they are contained; and since we have regularly issued a part every autumn, the whole of the papers read during a session are thus actually published within a few months of the close of that session, thus always bearing the date of the same year. Where, however, as in some foreign Transactions, the author's copies are sometimes circulated a year or more before the part they are contained in is actually published, the noting the date of the former appears to be essential.

We are this moment in receipt of the 4th, 5th, and part of the 6th volume of the Proceedings of the Entomological Society of Philadelphia in large 8vo, with a few plates; edited by Mr. Cresson.

Boston was not long in following the example of Philadelphia in the foundation of a central scientific body. The American Academy of Arts and Sciences was established at Boston in 1780, and a few years afterward commenced the publication of 4to Transactions, entitled 'Memoirs of the American Academy of Arts and Sciences.' A first series of four volumes, dated from 1785 to 1821, contains, however, but little on Natural History, and from that date there appears to have been a long interruption. In 1833 a new series was commenced, with improved typography and illustrations. Of this we have seven volumes, from 1833 to 1860, and the first two parts of the 8th volume, dated respectively 1861 and 1863, when as in the case of other scientific works, the publication appears to have been suspended by the effects of the civil war. Although the majority of the papers in these Transactions are on mathematical, physical, linguistical, and other miscellaneous sciences, yet, in Natural History, they contain D. H. Storer's extended synopsis of the Fishes of the United States, as well as several detached papers of his on the Fishes of Massachusetts, Nuttall's account of the Birds of Massachusetts, some smaller contributions to insect anatomy by Haldeman and J. Leidy, and several important Botanical papers, including Sullivant's Bryology and Hepaticology of the United States, A. Gray's Plantæ Fendlerianæ, Notes on the Botany of Japan, and several minor papers, Grisebach's Plantæ Cubenses Wrightianæ, and Eaton's Filices Cubenses Wrightianæ et Panamenses Fendlerianæ.

In 1846 the Academy also commenced 8vo Proceedings, published at shorter intervals than the Memoirs, and forming six volumes, from 1846 to 1865. Besides the ordinary reports of Proceedings and abstracts of the longer Memoirs, they include some entire papers of considerable length, especially J. D. Dana's Conspectus of the Crustacea of the Exploring Expedition under Wilkes, M. J. Berkeley and M. A. Curtis's Enumeration of the Fungi of the same Expedition, Tuckerman's Synopsis of North American Lichens, G. Engelmann's of North American Cactaceæ, and Anderson's of North American Salices.

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The naturalists of Boston further followed the example of Philadelphia in the establishment of a Society specially devoted to their own sciences. Their first efforts, however, were not successful. A Linnean Society of New England was formed in the winter of 1814–15, and during two or three years several meetings were held, papers read, and a few collections formed; but their only publication was a Report read at a meeting of the Society on the 18th of June 1817, on the part of a Committee appointed to inquire into the facts relating to the Sea-serpents supposed to have been seen on their shores. This report, a curiosity in its way, consists chiefly of the examination on oath of a considerable number of witnesses, the result of which appears to have led the committee to conclude not only that Sea-serpents of sixty feet or more in length had really been seen, but that a *Scoliophis atlanticus* about three feet in length, actually captured and described and figured in the report, was the young of the same species. After this effort the Society languished, and was dissolved in 1822, and the remnants of the collections were finally disposed of in 1830.

In that year a new Society was formed, which appears to have been yearly increasing in means and activity. The Boston Society of Natural History in 1834 commenced publishing papers communicated to them in the Boston Journal of Natural History, in 8vo, with a few plates; and the seven volumes issued up to 1863 are replete with valuable contributions to almost every branch of the Zoology of their country, with a few botanical papers, especially the Plantæ Lindheimerianæ by Engelmann and Gray. In exotic biology there also are papers by S. Cabot on the Birds of Yucatan, by J. Wyman on the Gorilla, by T. W. Harris on African Beetles, by A. A. Gould on African Shells, and by L. W. Bailey on Microscopical Organisms of Para. The Society also publish their Proceedings in 8vo, now in the 10th volume (1841 to 1866), which, besides abstracts, include a considerable number of short systematic enumerations, diagnoses, &c., both in Zoology and Botany. Of late years, however, the Society appears to have devoted its chief energies to the formation of a Library and Museum. The printed reports give a very flattering account of the new building into which the Library and Museum were moved in 1864, and which had been erected at a cost, including the cases, of above 100,000 dollars; the Library is reported as consisting in 1865 of above 7000 volumes, besides 1800 parts of volumes and above 2000 pamphlets, and the Museum as being far richer in most branches of Natural History than one should have supposed that a private Society would have been able to maintain. It will be interesting to watch in future years how far the resources they can depend upon will enable them to provide for the proper care and

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arrangement of their collections, which, to be useful, must be constantly and largely on the increase. The Treasurer's accounts show that besides the janitor (whom we should call porter) and some occasional help, there is but one paid officer, an eminent Entomologist, who is at the same time Custodian, Librarian, Recording Secretary, and Entomological Curator. For the thirteen other Curators of as many branches of Natural History, on whom alone depends the arrangement of the specimens, no remuneration appears in the accounts, whereas if the anticipations of increase sketched out in the Custodian's reports be realized, there must be full claims to the whole time of more than one Curator in most of these branches. The Society is making an experiment upon a large scale, but evidently depends much upon gratuitous aid; time alone will show whether that is less precarious on the other side than on this side of the Atlantic.

It is announced that the Boston Society's Journal is to be discontinued in the present form, but that the papers read will be published in quarto, under the new title of Memoirs of the Society.

The Harvard College at Cambridge contains a Museum of Comparative Zoology, which appears to be of great importance, and we understand that the very rich and valuable Herbarium of the distinguished Professor of Botany is also secured to the Botanic Garden of the University, but we know of no regular Transactions or Journals published in connection with the establishment.

The Lyceum of Natural History of New York was established in 1818, and commenced publishing the Annals of the Lyceum in 1823, in large 8vo, with a few plates. The seventh volume was completed in 1862, and the eighth is now in progress; they contain papers of considerable importance, chiefly in illustration of the Natural History of the States, including C. L. Bonaparte's Synopsis of North American Birds, some other papers in Ornithology by J. N. Lawrence and others, in Ichthyology by T. Gill, in Entomology by J. L. Leconte, J. W. Greene, and others, and numerous monographs and catalogues of shells by various conchyliologists. In Botany, Torrey's account of Rocky Mountain plants and United States Cyperaceæ, and L. de Schweinitz on North American Carices, occupy a considerable portion of the early volumes, beyond which there are only a few short communications from A. Gray.

The Elliott Society of Natural History of Charleston, South Carolina, published a volume of Proceedings, extending from November 1853 to December 1858, in 8vo, with a few plates. The most important papers are those of J. MacCrady on the Acalephæ of Charleston Harbor; among the smaller ones two are illustrated by plates, L. R. Gibbes on *Porcellana*, and a small list of rare plants by H. W. Ravenel.

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The Academy of Science of St. Louis was established in 1856, and obtained an act of incorporation early in the following year. They publish Transactions and Proceedings in one continuous series under the former title, in 8vo, with a few plates; the first volume, a thick one, extends from 1856 to 1860, and two parts of the second are dated respectively 1863 and 1866. The papers relate chiefly to North American Fossils, with a few on various physical subjects, and one on an Egyptian *Papyrus*. In Biology there is little beyond Engelmann's monograph of *Cuscuta*, and other communications by the same author, more or less connected with the North American flora.

The only scientific journal published in the United States which I have met with is that which has acquired a worldwide reputation under the title of the American Journal of Science and Arts. It was commenced under the editorship of Professor Silliman in 1818, and published in parts in 8vo. After some interruptions during the first year or two, owing to the difficulty of arranging with the publishers, it has regularly formed two volumes in each year. A first series, conducted by Professor Silliman, and after the first few years at his own risk as proprietor, was closed in 1846 with the forty-ninth volume, a fiftieth being soon after added, made up of a general Index. Professor B. Silliman was then associated with his father, who has since died, and now conducts it at New Haven in conjunction with Prof. J. D. Dana, with the assistance of several other Professors of Cambridge and New Haven. It is now in the forty-third volume of the second series, having undergone but little change beyond a reduction in bulk from 1864, necessitated by the difficulties resulting from the war. In this journal Biology occupies less space than other sciences; there are, however, a few valuable papers in both Zoology and Botany, and under the head of scientific intelligence, every number contains critical notices or abstracts of works and other doings in Biology, which are always of great interest on this side of the water as well as in the States.

Washington is the seat of an Institution which, although not coming precisely within the definition of a Scientific Society, contributes largely to the promotion of our own, amongst other sciences, by publications after the model of Transactions of Academies, as well as by other means. It is, moreover, of a nature so different from any we have in this country, that it may not be out of place to enter into some detail as to its history, as gathered from the official reports, as well as from what we have experienced of its action. The founder was an Englishman, James Smithson, described as a graduate of the University of Oxford, who, having devoted a long life to the pursuit and encouragement of science, bequeathed his large property to the

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United States, in trust, to found, at Washington, an Institution which should bear his name, and have for its objects the increase and diffusion of knowledge amongst men. The greater part of the property was realized in 1838, but considerable delay occurred in its application, owing chiefly to the great difference of opinion that prevailed as to the character to be given to the Institution, the objects of which were so vaguely indicated by the testator under these two heads, the increase and the diffusion of knowledge. At length, on the 10th of August, 1846, an Act of organization was passed by Congress, and the 'Smithsonian Institution for the increase and diffusion of knowledge' was established at Washington, under the management of a Board of Regents, fifteen in number, consisting of the Vice-President of the United States, the Chief Justice of the Supreme Court, and the Mayor of Washington, as *ex officio* members, three appointed by the Senate from its own body, three by the House of Representatives from its members, and six citizens appointed by a joint resolution of both houses; several of the principal executive officers of the States to be *ex officio* members, with occasional honorary members to be elected by the Regents. The total amount of the bequest received into the United States Treasury on the 1st of September, 1838, was 515,169 dollars, or above £125,000, deposited in the United States Treasury, and producing an annual income of $30,910, payment of which they have succeeded in obtaining in coin, making nearly £7000. There was also at the time of the establishment of the Institution an accumulation of interest amounting to $242,129, or nearly £55,000. For the application of these sums different schemes were strongly advocated by opposing parties. One, which found most favor with the national and popular party, was the formation of a general Library, Museum, and Gallery of Art in a building which, by its dimensions and architectural design, should be an ornament to the city, and a splendid memorial of the liberality of the founder; whilst others, entering more into the spirit of the bequest, urged that Smithson's object could never have been the glorification of Washington, or the localization of knowledge, but the promotion of science wherever or by whomever it was or might be pursued, and that the fund ought therefore to be employed in the encouragement of scientific and literary researches, and to the publication and transmission of their results to every quarter of the globe where civilization could reach, with such buildings, collections, and local appliances only as should be immediately subservient to these objects. At length a temporary compromise was effected between the advocates of local appliances and of active operations. It was determined that, besides the deposited capital which, by the Act, was to be left untouched, a portion of the income was at

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first, at least, to be annually invested, till the plans should be matured by experience, and that, of the remainder, one portion was to be expended in the formation of the library, museum, and gallery required by the Act, and the other in the more active operations recommended by men of science, whilst the accumulations already in hand were to be applied to the erection of the building, the relative proportions being left to the discretion of the Regents. During the first year the popular party found favor with the majority of them, and large sums were squandered on the building and local objects; but in time sounder views prevailed; the active operations have been extended with a success we all can appreciate, and the Institution has now attained a position of practical eminence and usefulness to science in strict conformity with the evident intention of the founder. This happy result (as far as I can judge from this distance, and without any personal communication) must be attributed mainly, if not entirely, to the well-devised plans of the Secretary, Prof. Henry, and to the zeal, activity, and perseverance with which he has devoted himself to their practical carrying out during the twenty years that have elapsed since the foundation of the Institution.

The edifice was originally to have been "a suitable one, constructed in plain and durable materials;" but the Building Committee, giving way to local influences, adopted a plan described in the Secretary's reports as being in the Lombard style, with useless buttresses, turrets, and towers, the convenience of the interior entirely sacrified to architectural display; a judgment which an inspection of the plans and elevations given in R. D. Owen's 'Hints on Public Architecture' fully confirms. The money thus lavished on the freestone facade absorbed so much of the sum at command that the interior had to be run up in wood, lath, and plaster. The two wings were thus completed, and the main building presenting a frontage of 200 feet was far advanced, when the woodwork gave way, and had to be replaced with fireproof materials at very large extra cost, the roof alone of this main building remaining in wood. In that roof, where little danger was forseen, a fire broke out through the carelessness of some workmen in June 1864, destroying much private property, official papers, &c., although the most valuable stores, library, and collections of the Institution were preserved. After these disasters the ruling powers appear at length to be convinced that in the work of restoration and completion they must look more to substantial durability than to architectural effect; but they are sadly hampered by the size of the building, so much beyond their real wants, and its costly style, which cannot now be altered. In this building were to be deposited:—

(1) A general National Library, with provisions by which

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the Institution would be encumbered by all the trashy productions of the day, without means of procuring those really valuable to science; this they have succeeded in warding off, and are endeavoring to limit their library to works bearing on science. They have bestowed especial pains, and appear to be already rich in Proceedings and Transactions of learned Societies and other serials connected with science; and it is hoped that they will be gradually relieved from their general and useless literature by the transformation of the Congress Library into the great National United States Library, instead of attempting to impose the burthen on a private Institution incapable of sustaining it.

(2) A general Museum, as comprehensive and multifarious in its objects as our own British Museum, with a similar aim at popular display. But the impractibility of such a Museum, which would soon absorb an annual income equal to their whole capital, is now felt, and the collections are to be henceforth restricted—1st, to those made by the United States Exploring Expedition, the care of which has been imposed on the Institution by Congress; 2nd, a limited museum of type specimens, principally of the products of the American Continent, or such as are thought of especial interest as illustrating the Smithsonian publications; and 3rd, collections for distribution, to which I shall presently revert.

(3) A Gallery of Art; but the absurbity of imposing upon such an Institution the care and maintenance of a National Gallery is so evident, that the collections in this respect have been limited to some plaster casts of distinguished individuals, and a very few pictures they could not refuse the charge of.

In the active operations of the Institution the knowledge they are called upon to promote has been divided, as in the great Academies of the Continent of Europe, into the three great branches of Physical Science, Moral and Political Science, and Literature; the Fine Arts being nominally included in the latter class, but really somewhat extrinsic in character, and practically passed over. What has been effected by the Institution in the second and third classes, it is beyond my province to inquire; and even in the Physical class I do not venture to express any opinion on their efforts in the promotion of Meteorological, Astronomical, and other Physical observations. In Biology their exertions have been directed to the publications of Memoirs, Reports, and other papers, to the promotion of Exploring Expeditions, as well as of local investigations, to the distribution of specimens, and to the facilitating the interchange of publications and other vehicles of knowledge.

The principal publications of the Institution are in two series, the one in 4to, the other in 8vo, corresponding generally to the

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Transactions and Journals of Scientific Societies. The 4to series, entitled 'Smithsonian Contributions to Knowledge,' copiously illustrated by well-executed plates, has now attained its 15th volume (although 14 only have as yet reached us,) the first having been published in 1847, less than a twelvemonth after the foundation of the Institution; the 8vo series was only commenced in 1862, without plates, and now forms six large volumes. In these two series Physical Sciences and Natural History (Biology, Paleontology, and Geology) occupy nearly equal proportions; there are also extended ethnological and philological Memoirs, and a few smaller ones on miscellaneous subjects. The Biological papers, whether systematic or physiological, are almost entirely illustrative of the fauna and flora of North America, the most important of which are (including two or three now in the press) Monographs or Catalogues of North American Bats by H. Allen; Mammals and Birds by S. F. Baird; Oology by T. M. Brewer; Reptiles by S. F. Baird and C. Girard; Cottoid Fish by C. Girard; Marine Invertebrata and Crustacea by W. Stimpson; Shells by W. G. Binney, P. P. Carpenter, T. Prime, W. Stimpson, and G. W. Tryon; Insects by J. L. LeConte, H. Hazen, H. Loew, F. E. Melsheimer, J. G. Morris, R. Osten Sacken, H. de Saussure, S. H. Scudder, and P. R. Uhler; in Animal Physiology by J. Dean, J. Jones, S. W. Mitchell, G. R. Morehouse, and J. Wyman; in Insect Embryology by L. Agassiz, and in Microscopic Biology by J. W. Bailey and J. Leidy. In Botany we have W. H. Harvey's Nereis Boreali-Americana, illustrated by 50 plates, A. Gray's Plantæ Wrightianæ Texano-Neo-Mexicanæ, and three papers by J. Torrey on Californian plants. Each one of these papers is separately paged in order to facilitate their separate distribution.

The Smithsonian reports form a volume in 8vo for each year; they contain, besides the official reports of the proceedings of the Institution for the preceding year, extracts from correspondence, reports of explorations, &c., several important scientific papers translated from foreign languages, and some original ones on various scientific subjects. These reports to Congress are printed at the expense of Government, with the exception of a few occasional woodcuts supplied by the Institution.

In the way of promoting explorations and collection of observations, the efforts of the institution have hitherto been judiciously confined as strictly as possible to America, Northern and Arctic, Central and Southern; but in this field they have done much, and the exertions of the Institution, with considerable means at its command, cannot but remind one of the equally strenuous and successful exertions, as to one branch at least of science, of a single individual in our own country, the late Sir William Hooker, or of the more general ones of our

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Royal Geographical Society. On this subject I cannot do better than quote a passage from the Secretary's Report of March, 1865, when speaking of the aid afforded in the organization of government explorations by land and by sea:—"Whether by official representations to the heads of departments or personal influence with officers and employés, it has secured the engagement of individuals competent to collect facts and specimens; it has instructed persons thus engaged and others in the details of observation, it has superintended the preparation and in some cases borne the expense of the necessary outfits, has furnished fresh supplies from time to time to the collectors while in the field; received the collections made and preserved them for future study, or at once consigned them to proper persons, both at home and abroad, for investigation, directing the execution of the necessary drawings and engravings for the reports, and finally superintending the printing and even the distribution of any available copies of the completed works to Institutions of science. Prior to the establishment of the Institution but little had been done by the Government in the way of scientific explorations, with the exception of that under Captain Wilkes. But since then, nearly every United States expedition, whether a survey for a Pacific Railroad route, a boundary line, or a wagon route across the Rocky Mountains, or an ordinary topographical expedition, has been influenced or aided more or less as above stated. Besides these, similar explorations have been carried on without any reference to Government, and either entirely or in a great measure at the expense of the Institution and always at its suggestion." An enumeration follows of above twenty of the more important of these expeditions directly organized by the Institution in the northern and western portions of North America, in Mexico, Central America, Cuba, Jamaica, and Bolivia.

In making collections by means of these expeditions or otherwise, the object has not been so much to supply a large museum with permanent specimens, or duplicates for regular exchanges, as to distribute the specimens where it is thought they might best advance the cause of science, by being most accessible to the largest number of students engaged in original investigations. Much has been done in this way in the encouragement of local societies in rural districts for the collection of specimens and the recording of natural phenomena; and, as far as botany at least is concerned, the collections that come to Europe show that the official statements on this head are not extravagant boasts.

I have said that in its Library the Institution is endeavoring to obtain a complete collection of Transactions and other works of a serial character issued by learned bodies. This they ex-

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pect to obtain chiefly by a liberal system of exchange, and for that purpose it is now in correspondence with upwards of 1200 of the Societies, Public Libraries, and principal Universities of of the Old World.

The last head I shall refer to is that of International Exchanges. From the first, one of the special objects of the Secretary's plans was to facilitate the direct correspondence between the learned institutions and scientific men of the two worlds, and the free exchange of their publications. Year by year the plans for this purpose have been modified and improved until they have attained an extent which seems only to require control to guard against its being abused by private interests under the name of science, or, perhaps still more, of benevolence. At the present time the Institution receives, at periods made known through its circulars, any books or pamphlets of scientific, literary, or benevolent character which any institutions or individuals in America may wish to present to a correspondent elsewhere, subject only to the condition of being delivered in Washington free of cost, and being accompanied by a separate list of the parcels sent. Where any party has any special works to distribute, the Institution is prepared to furnish lists of societies or persons to whom they might be usefully sent. The articles and volumes, when received, are assorted, packed, and dispatched to the agents of the Institution in London, Leipzig, Paris, and Amsterdam. The boxes are there unpacked, and the contents distributed through the proper channels. The returns for these transmissions are received by the same agents, packed and forwarded to Washington, from which point the parcels for other parties are sent to their proper destination. All the expenses of packing, agents, freights, &c., between those four towns and Washington are borne by the Institution, the parties concerned only paying the local carriage from or to these great centers. In this interchange the Institution has obtained special facilities on the part of custom-houses, railroad and steamboat companies; and the scientific and literary world have largely availed themselves of this useful system. The number of packages reported as dispatched to foreign countries from Washington in 1864 was 1011, contained in 63 boxes, weighing 20,500 lbs., whilst the packages received in return was 2482, exclusive of those for the Smithsonian library.

We have nothing of the kind in this country, and the difficulties of interchange of books and specimens with the Continent are much felt; the comparative cheapness of freights is more than made up by the complicated agencies and other extra charges, which can scarcely be avoided even by the few who are initiated into the secrets of the business. A box of specimens for Hamburg, which the carrier took to the wrong continental

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steamboat agent in the city, cost me 22s., when for 25s., I might have gone myself to Hamburg and taken the box with me as luggage. The sending one or two volumes, or a small packet of specimens into Germany, is often prevented by the difficulties and expense attending it. It is not to be expected that any Association in this country should be endowed with funds especially devoted to the diffusion of knowledge, enabling them to undertake the transmission gratis of scientific works and specimens; but it appears to me that if, for instance, the six Scientific Societies which are in future to be assembled in this locality were to join in salarying agents in London and in three or four of the principal centers of science on the Continent, who should receive for transmission, pack, and periodically despatch scientific parcels, and distribute return packages, charging to individuals their proportions only of actual disbursements, the gain to science would be considerable and the charge to each society but small.

In glancing over the general tendency of the biological papers contained in the works I have ennumerated, it will be seen that, although it is scarcely half a century since our American brethren applied themselves in earnest to the investigation of the natural productions and physical condition of their vast continent, their progress, especially during the latter half of that period has been very rapid until the outbreak of the recent war, so deplorable in its effects in the interests of science as well as on the material prosperity of their country. That is, however, now fortunately over; and although the means of every scientific institution are still sadly crippled by the high prices and heavy duties resulting from that war, yet many of them appear to be resuming their former activity; and it is to be hoped that they will now again receive every encouragement, public and private, in the vigorous prosecution of their researches. The peculiar condition of the North American Continent requires imperatively that its physical and biological statistics should be accurately collected and authentically recorded, and that this should be speedily done. It is more than any country, except our Australian colonies, in a state of transition. Vast tracts of land are still in what may be called almost a primitive state, unmodified by the effects of civilization, uninhabited, or tenanted only by the remnants of ancient tribes, whose unsettled life never exercised much influence over the natural productions of the country. But this state of things is rapidly passing away; the invasion and steady progress of a civilized population, whilst changing generally the face of nature, is obliterating many of the evidences of a former state of things. It may be true that the call for recording the traces of previous conditions may be particularly strong in Ethnology and Archæology; but in our own branches of the science,

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the observations and consequent theories of Darwin having called special attention to the history of species, it becomes particularly important that accurate biological statistics should be obtained for future comparison in those countries where the circumstances influencing those conditions are the most rapidly changing. The larger races of wild animals are dwindling down, like the aboriginal inhabitants, under the deadly influence of civilized man. Myriads of the lower orders of animal life, as well as of plants, disappear with the destruction of forests, the drainage of swamps, and the gradual spread of cultivation, and their places are occupied by foreign invaders. Other races, no doubt, without actually disappearing, undergo a gradual change under the new order of things, which, if perceptible only in the course of successive generations, require so much the more for future proof an accurate record of their state in the still unsettled condition of the country. In the Old World almost every attempt to compare the present state of vegetation or animal life with that which existed in uncivilized times is in a great measure frustrated by the absolute want of evidence as to that former state; but in North America the change is going forward as it were close under the eye of the observer. This consideration may one day give great value to the reports of the naturalists sent by the Government, as we have seen, at the instigation of the Smithsonian Institution and other promoters of science, to accompany the surveys of new territories. For present purposes we want very much a digest of the new observations. Synopsis of some classes of insects and other animals appear indeed in a complete, or nearly complete form in the Smithsonian and other publications above mentioned; but we have as yet no complete flora of North America. The admirable one began so many years since by Torrey and Gray has been so long interrupted that it requires rewriting from the beginning; and there is no greater service to the science that the distinguished Cambridge Professor could now render than the resumption of that work, in any, however much abridged form.

The American Museum reports suggest some topics worthy of consideration with regard to the general question of Natural History Collections. The first thing that strikes one is the want of a National Central Museum for the reception of as complete a representation as can be obtained of the North American Fauna and Flora, with so much at least of foreign specimens as may be required for comparison and generalization. For this they seem to have depended on the efforts of private scientific bodies; but the progress of these, so far as they have gone, seems to corroborate the experience of the Old World, that the useful maintenance of such an establishment is absolutely hopeless unless it be supported at the public expense, or by the an-

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nual proceeds of a sufficiently large inalienable capital. In America, as in Europe, almost every Natural History Society, small or large, begins by contemplating the formation of a Museum, undefined as to limits; contributions are invited and donations thankfully received from every quarter, without reference to value or practical utility. At first, whilst the Librarian, Secretary, or other manager takes a personal interest in the arrangement and exhibition of the objects received, when donors can bring their friends to see their contributions displayed on shelves or in glass cases with their own names paraded on the cards, when most of the members of the Society have the new feeling of a personal share in the ownership of the collections, when the number of specimens received is blazoned forth as a matter of pride and gratification, these incipient museums may have considerable influence in stimulating collectors and observers of nature. But after a time these collections outgrow the Society's means, the specimens which may be required for study or comparison are encumbered by a mass of trash presented by persons who do not know what else to do with it, or who have attached a false value to the fruits of their own labors, the permanent officer can no longer have time to select for exhibition what is worthy of it, nor to arrange those which might be available for reference, and the Society cannot afford to maintain the necessary staff of keepers, even if they have a building large enough for the purpose. Packages and specimens are, however, still received, exhibited at meetings to elicit formal thanks, and then consigned to oblivion and decay in cupboards and garrets, the members generally taking no further interest in what they can make no use of. If afterwards attention is called to this state of things, it may be felt that something must be done; the gratuitous aid of patriotic members is called in, and the museum may be more or less purged of trash and partially arranged. But gratuitous aid, like voluntary subscriptions, is generally given on the spur of the moment, and can never be depended on for long continued and ever increasing demands; the collections relapse into a condition worse than the previous one, till at last the Society is obliged to dispose of them as a clog on, instead of an aid to, their operations. Such is the history of many a museum I could name on the Continent and at home, including our own, and such seems destined to be the career, on a large scale, of the Boston Society, notwithstanding its large invested funds, if something is not done to give it a permanent independence of individual disinterested efforts. It is now in the gratuitous aid period; but when its present stores are doubled or quadrupled, when the thirteen or fourteen unpaid curators must not only give their whole time to it, but require each of them one or more assistants to do the work usefully, it will not be done at

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all; and unless the Society receives that extensive support which can only be expected from the State, stowage, neglect, and destruction must ensue. It is no doubt considerations such as these that have induced the Smithsonian Institution to repudiate the burthen attempted to be imposed on them of a National Museum which even the whole of their income would be insufficient to maintain.

There is another class of museums which the Smithsonian Institution appears to be promoting and assisting, with what results I have not sufficient means of judging; these are local museums on a smaller scale in the smaller cities and provincial towns. We have many such in Europe, both on the Continent and in our own country, and if judiciously formed and adequately maintained, ought to be very useful in encouraging the taste for observation at home, and giving the scientific visitor from a distance authentic information on the natural history of the district. But too many of them depend on the fluctuating support of voluntary contributions, and follow the fate of museums of societies. I have had occasion to go over many of these local museums in various parts of the Continent and some of our own, and it had been my intention to have collected information, and in one of my addresses to have prefaced some general observations on the subject, with a detailed review of all our provincial Natural History museums and Associations; but so many of them are unfortunately more or less in a state of collapse or uselessness, that I feared that special notes might be invidious. I may perhaps be allowed, however, generally to remark, that it appears to me that local provincial societies cannot better apply their funds and influence than in the establishment, on a permanent and independent footing, of a public museum, confining their publications to matters of purely local interest, which the general naturalist is not to be called upon to notice; that this museum should aim at completeness in representing the local district; that exotic specimens should be restricted to such a limited number of representative types or specimens for comparison as their means will afford, selected solely in proportion to their utility in the museum, without reference to the individuality of the donor, or, if a certain number of complementary specimens must be retained for a time in order to keep up the public interest in the establishment, such specimens be unhesitatingly expelled as soon as the cause for retaining them is gone.

In conclusion, I may perhaps be excused in alluding to some general principles in the management of large museums, which are inculcated by the Smithsonian Institution, more or less followed on the Continent, formerly almost ignored with us, but now more generally recognized. These are liberality of exchanges, facilities for study, and rejection of trash, principles

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which it may be hoped are even gaining upon that most essentially conservative establishment, our gigantic and, I might almost add, all-grasping British Museum. The large sums annually voted for its support by the nation justify, indeed, not only the exhibition on a most extensive scale of attractive specimens for the occasional instruction or excitement to observation they may give to the general public, but also the concession to the popular party of a rare show for the thousands of gazers who would otherwise congregate for less harmless amusements; but a large proportion of the support or contributions to the museum is granted or given in the name of Science, and Science has a right to its full share in the consequent benefit. Whether Natural History be or not under the same roof as Art, Literature, and Archæology, Science has a claim upon Parliament to provide buildings and maintain a staff adequate to the scientific arrangement of the collections; and she has, I think, also a right to call on the management, be they a composite Board of Trustees or individual responsible heads, to reserve days, accommodation, and specimens for examination and study, to allow of the requisite appliances of light and heat in the process, to cause the stores that have accumulated for more than half a century to be turned out of their hidden repositories, to have what is useful to scientific researches rendered accessible for the purpose, the surplus duplicates employed in a liberal system of exchanges, with an eye quite as much directed to the distributing them usefully as to the pecuniary value of any expected return; and to authorize the consigning to the dust-cart all absolute rubbish occupying valuable space.

Art. XXXIII.—*The Action of Sunlight on Glass;* by Thomas Gaffield.

[Concluded from page 252.]

The comparative power of glass of different kinds to transmit the actinic rays I have tested, by placing underneath pieces of each kind, pieces of easily changing glass, (white plate or Belgian sheet glass,) exposing them one year, and noticing, at the end of that period, the comparative depth of the yellow or pink color to which the under pieces had changed. The result of my experiments proved that the most easily transmissive of the colorless glasses were the English crown, French plate, two kinds of white crystal sheet made in Massachusetts, (from the celebrated Berkshire white sand,) the New Jersey sheet glass, one kind of English plate, and one kind of Belgian sheet, and about in the order which I have named them.

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Of the colored glasses, the blue transmitted the most, the purple less, the red and orange the least, the glasses under these two and the yellow and green showing little or no change.

This last experiment proves the propriety of the preference given by photographers to blue glass for skylights, because it transmits the blue rays, which exert the most actinic power. But it may be added, that a colorless white glass, or bluish white,—if one which will not change by sunlight to a yellow or rose color, owing to the presence of manganese, or any other cause,—is equally good, as it will transmit all the rays, and among them, the actinic or blue ones. In proportion as any kind changes to a yellow or rose color, it will lose its power of transmission, and its value as photographic glass. I have seen specimens of the two kinds of white crystal sheet made in Massachusetts, before alluded to, which answered the demands of photographic artists. Of foreign glass, I have noticed a fine bluish white sheet, made lately without manganese, from a certain excellent manufactory in Belgium, and one kind of English crown glass.

Should plate glass be required, the most permanently enduring, or least likely to assume a yellow color, are a superior kind of white plate, made by the French and Belgian Plate Glass Companies, and an excellent quality of German crystal plate, made at a long established factory in Hanover.

I desire to say here, however, that it is not the place where any glass is made, which determines its good character, but the actual constituent materials and the superiority of its manufacture.

Manufacturers are frequently changing their mixture or "batch," so that any results given with one set of samples might differ from those made with another set, from the same manufacturers. For this reason, in noticing any differences which may occur in experiments made by any of our readers, this fact should be considered as an explaining cause.

I have seen specimens of glass from a factory which changed to a yellowish tinge in a few months, others which changed to a purplish hue, and still others from the same factory, which hardly changed at all. A difference in the mixture, (or batch, as it is termed), makes a difference in the tinge of the specimens from the same factory, both before and after exposure to sunlight. The chief points for photographers are to get glass made from as pure materials as possible, of as light a color as practicable, and free from oxyd of manganese. A glass like either of those named above, as most easily transmitting the actinic rays, might be good for one year or more, and then become very much injured for photographic effects, by the change of color to yellow or pink by sunlight.

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Any photographer can make these observations practical, by testing the action of sunlight for six months or a year, on all the specimens offered him for sale. And all manufacturers can make them practical, by making their glass of pure materials, which will not have to be "doctored," to use the glass-makers' term for the use of manganese; or by allowing the glass to assume its natural color, even if it be a little blue or green, rather than to run the risk of its subsequent change to yellow or purple by exposure to sunlight.

In the Comptes Rendus for January 14th, 1867, Pelouze says, (and we believe he is the first and only writer who has made this observation):

"Exposure to red heat decolorizes the glasses which have been made yellow by sunlight, or to speak more exactly, they retake the light green shade which they had before exposure. A second exposure to sunlight produces a second coloration, similar to the first, and a red heat makes it disappear again. These phenomena can be reproduced indefinitely. The glass preserves its transparency and does not give place to any strise or bubbles." He also says:

"I possess specimens of glass rendered violet by sunlight. All present the property of being decolorized by heat. A temperature of 350 degrees is not sufficient. It is necessary to have that employed in the reheating of glass in general, and that is in the vicinity of red heat. The glass decolorized by heat when exposed to sunlight retakes the amethyst color which it acquired the first time, loses it anew when it is heated; and these curious phenomena can be reproduced without cessation."

In confirmation of this most interesting statement of Pelouze, I have exposed in a glass stainer's kiln, several specimens of glass which had been changed by the action of sunlight, some to a yellow and some to a purple color. The exposure to an extreme red heat made the glass assume, some a white, some a yellowish white, and some a green color, which were probably the original colors. These specimens were taken from windows where they had been exposed from a few years to more than half a century. Further experiments, which I have already commenced, will show whether we can reproduce the exact original colors by heat, after being changed by exposure to sunlight.

We have in the same kiln exposed some dozen original and unexposed specimens of what are called colorless window glasses of different kinds and shades of color, and found them unchanged in the slightest degree by the action of great heat, while similar specimens have been changed in a few days, weeks or months, by the simple action of the sun's rays. Fifteen specimens of really colored glasses, (red, green, yellow, &c.,) have

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been exposed in the same way without any change of color, except a very slight one in a few specimens which were burnt or over-heated.

In Poggendorff's Annalen, Berlin, of May 1st, 1839, is recorded the following interesting fact by A. Splittgerber:

"I would mention a curious fact, in which the sunbeams have, if I may say so, done something in the art of penmanship; not only on the surface, but by inscribing characters through the body of the glass; and, though the matter is based upon causes well known by experience, yet there has probably never before been so striking an instance of their effect known. I am in possession of a plate of glass which was used as a window pane for more than twenty years, and on which was an inscription in gold letters. This inscription was taken off by grinding the plate on both sides, and polishing it so as to have a new surface. When the glass had been polished, the inscription could again be clearly seen. The parts which had been under the letters remained white, while the remainder of the plate had assumed a violet tint, in consequence of the manganese it contained, a coloring which permeates the whole mass, as the grinding of the surface proved. The uncovered part of the plate, especially when laid upon a white background show the clearly readable characters."

The same or a similar instance is related by Dr. Herman Vogel in the Photographische Mittheilungen, Berlin, of Sept., 1866.

Desiring to produce a similar result, we made an inscription on a piece of Belgian sheet glass, in part with gold and silver leaf, and in part with black and white paint. The gold and silver leaf were soon washed off, but the black and white painted letters remained, and being removed after an exposure of nearly two years, the words stood out in clear contrast and full proportions, the inscription being in the original color of the glass, and the surrounding portions having been changed by the action of the sunlight to a purple color.

A very interesting experiment can be made, to show the gradually increasing effect of the sunlight on glass, by taking a piece of easily changing glass, say 4×20 inches, painting black a strip 4×2 inches at each end to preserve the original color, and then exposing the strip to sunlight. At the end of one, two, four, six, eight and ten months, one, two and three years respectively, cover with black paint a strip 4×2 inches, and at the end of three years remove all the paint, and you will have, in a single piece of glass, the original color and all the gradations of change effected by exposure from one to thirty-six months. I have made a similar one with Belgian sheet glass exposed nearly two years. It is one of those interesting experiments which speak for themselves, and defy suspicion or contradiction.

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I have made an experiment for one year with two kinds of easily changing glass out of doors, and out of the direct rays of the sun, and found that they were both slightly affected, and changed toward a yellowish color. I did not expect any change, but can, perhaps, properly account for it, on the ground that it was the result of the action of diffused sunlight. It is barely possible that the sun may for a few minutes in some days of the year have cast some reflections when I was not present, in the dark corner in which I placed my specimens.

It may be, that the action of the sun's heat produced the slight effect noticed. If so, it would be an interesting confirmation of Tyndall's experiments, and of his theory of the correlation of forces. I do not consider my single experiment as entirely conclusive, and shall make others, which will give us more material for proper theories and conclusions.

The experiments which I have carried on for four years embrace one specimen of optical glass, a few kinds of flint glass and glass ware; sixteen kinds of French, Belgian, German and English plate glass, four kinds of American, English, French and Belgian rough plate, two of American and English crown glass, ten kinds of American, Belgian, French and English white sheet glass, four kinds of American, Belgian and English ordinary sheet glass, fifteen kinds and shades of English colored glass, four of opaque, white enamelled and ground glass, and one piece of the rough metal of American sheet glass; in all, about sixty varieties.

I have watched and recorded in some experiments, the results from day to day, in others from month to month, and season to season. I have now commenced a series, in which I may record results from year to year, for ten years or more. In these, it may be found that specimens of what are called colorless glasses changed to a yellow color by exposure for a year, may by much longer exposure be turned to a yellowish pink and a purple. And some which have been entirely unaffected, may be affected by an exposure for ten or twenty years. Perhaps some of the colored glasses may show signs of a change of hue or shade.

These new experiments include rough and polished plate, crown, cylinder, ground, enamelled and colored glass. I have also begun to expose *under* several of these kinds of glass, pieces of easily changing glass, which I shall take in from year to year, these *under* pieces showing the power of these glasses above them to transmit the actinic rays.

The most easily changing glasses are a certain kind of white plate, which changes from a white to a yellowish color, and a certain kind of Belgian sheet, which the manufacturers used to make of a brownish yellow, (they now make it of a bluish or greenish hue, and it is not so easily changed,) which changes to

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a flesh color, or a pinkish hue. I have accordingly taken these two kinds, for my *under* glass experiments. Under each of several kinds, to be exposed from one to ten or twenty years, I have placed pieces 4×2 of the white plate. I shall take in one piece at the end of the first, second, third, fourth, sixth and tenth year. These six lights will show the increased action of the transmitted rays from year to year. By comparing the different series with each other, one can perceive the comparative actinic power of each kind of glass, or rather, their comparative power of transmitting actinic rays.

Another interesting *under* experiment is the following. I have placed under one piece of each kind of glass exposed, a piece of easily changing glass, which I shall take in at the end of the year.

At the beginning respectively of the second, third, fourth, sixth and tenth years, I shall place under the same piece, another strip of 4×2 inch glass, taking in each piece at the end of the year of its exposure. This series will show the diminishing or increasing power of the glasses under which they have been exposed, to transmit the actinic rays; in other words, will show whether exposure to the sun increases or diminishes the actinic power of the glasses exposed, and renders them better or worse for photographic purposes.

I have taken a piece of 4×18, of easily changing white plate, painted with black paint two inches of each end, to preserve the original color, and exposed the piece. At the end of the year, I shall paint over two inches more of the glass. At the end respectively of two, three, four, six, and ten years, I shall paint over two inches more. At the end of this time, or a longer term, I shall remove all the black paint, and on one light, I shall have all the grades of changed color and shade produced by their different lengths of exposure. I shall lay aside one piece of 4×18 white plate, taken from the same sheet with the exposed light, in order to compare the original with the changed specimen.

I have painted and exposed, just in the same manner as above described, a piece of 4×16 of easily changing Belgian sheet glass.

To show a speaking proof of the painting power of the sunlight, I have taken a piece of 4×6 Belgian sheet and covered it with a thin plate of brass, having the following letters cut out of it: T. G., Jan. 1, 1867. I have taken another piece 4×6 Belgian, and stuck on with gum shellac the two letters T. G. After exposure of one year or more, the removal of the brass plate and letters will show in the former case, rose or purple colored letters on a brownish yellow ground, and in the latter, brownish yellow letters on a rose or purple colored ground.

A similar experiment as the above, I have commenced with

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two pieces of white plate, and the simple letters T. G., without the date. The result of the experiment in a year or more, will be to show in one case, yellowish letters on a light colored ground, and in the other, light colored letters on a yellowish ground.

I have thus given, as briefly as possible, and yet as fully as desirable, an account of my past and present experiments. New ones are suggested from year to year. I trust that this interesting field for observation and experiment may be worked in other countries. There is ample room for research in the application of chemical knowledge, of qualitative, quantitative, and spectral analysis, and of photogenic tests, to discover the exact action and causes of the interesting effects of the sun's rays, which have here been noticed.

Theories.—The interesting phenomena of which I have given an account, have given rise to many theories to account for their cause. Some attribute them to the presence of oxyd of iron, and some to oxyd of manganese. Exactly how the change takes place is a question on which writers differ, although it is my opinion that the precise explanation can only be given after a multiplication of experiments, and a thorough examination of exposed and unexposed specimens of glass by quantitative and qualitative analysis, and perhaps by spectral analysis and observation of photogenic effects, or photogenic tests.*

We will briefly state the part which the oxyds of iron and manganese play in glass making. In almost all kinds of window glass, and in some poorer qualities of flint glass, and glass ware, materials are used which are not perfectly and chemically pure. The sand, the carbonate or sulphate of soda, and the lime, one or all, contain slight impurities of iron, the protoxyd of which gives glass a green color. To correct this, after the batch is partially melted, a little oxyd of manganese, called *glass-maker's soap*, is put into the crucible or glass pot; some of the oxygen of the manganese flies off to the iron, and converts the protoxyd into peroxyd of iron. The peroxyd gives a yellowish color to the glass, and this, being complimentary to the natural pink of the manganese, is neutralized, and the glass is thereby made of a light color. When the sunlight acts upon glass thus made, the nice equilibrium between the oxygen of the iron and the manganese is disturbed, and sometimes the yellow, and sometimes the pink or purple color is produced. I have produced all shades of the purples, running from

* Since writing the above, by the kindness of Mr. John A. Whipple, the distinguished photographer of Boston, I have been enabled to show, by the comparative darkening of sensitive paper under several exposed and unexposed specimens, the effect of exposure to sunlight for one year. The loss of actinic power, or power to transmit the actinic rays, was in proportion to the change of color. This was in some varieties of glass quite perceptible, but in all will be more so after an exposure of several years.

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pale lavender, into the lilac, mulberry, flesh, amethyst, rose, violet, pink and deep purple. I have produced, or seen specimens, showing all shades of the yellow, from the brownish yellow, up to the brightest gold color, and I have several series of specimens, in which the green has gradually changed into the yellow, and the yellow gradually run into the pink and purple.

Pelouze, in an article in the Comptes Rendus, of Jan. 14th, 1867, sets forth the following theory.

"There is in glass colored yellow in sunlight some protoxyd of iron and sulphate of soda. Light provokes between these matters a reaction from which results peroxyd of iron and sulphid of sodium. The heat brings about an inverse reaction and reproduces sulphate of soda and protoxyd of iron. From thence comes the return of the glass to its primitive color. Analysis comes to the aid of this theory in demonstrating in glass rendered yellow by sunlight, the presence of an infinitely feeble, but still very sensible proportion of a sulphid, whilst the reactions do not show the slightest trace in the same glass before their exposure."

"It may be asked, why glasses colored by the reduction of the sulphate, or the direct introduction of a sulphid into their mass, resist an equal or superior heat to that which produces the decoloration of glass become yellow in sunlight. Here is the answer. In glass made yellow at a high temperature by the reduction of sulphate, the iron is found in a state of protoxyd, which cannot react in any degree upon the sulphids. Therefore the glass remains colored. In glass made yellow by sunlight, the iron is peroxyd and in consequence, in a condition to change the sulphid into sulphate, when we expose the glass to the action of heat."

In reference to glass made violet color by sunlight, he says, "The coloration seems to be due to the fact that the peroxyd of iron gives up a part of its oxygen to the protoxyd of manganese conformably to one of the two following equations.

$$Fe^2O^3+MNO=2(FeO)+MNO^2$$
$$\text{or}\quad Fe^2O^3+2(MNO)=2(FeO)+MN^2O^3.$$

The reheating of glass, that is to say, the action of a temperature of red heat, produces an inverse reaction, which explains the decoloration. In which we have

$$2(FeO)+Mn^2O^3=Fe^2O^3+2(MnO)."$$

Bontemps, in an interesting article in the Comptes Rendus of Feb. 4th, 1867, attributes the changes in color to the presence of oxyd of manganese. He also remarks that he thinks that the violet color occurs only in glass in which the silicates have a base of potash, and the yellow in cases where soda is used. I doubt the correctness of this opinion, as I am quite sure that I

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have several specimens colored violet, which contain no potash at all in their composition.

I have also specimens which are colored both yellow and violet in the same piece, the yellow portion in one case having been produced by a certain length of exposure, and then having been covered with black paint, while the violet portion was produced by longer exposure.

As before stated, I have noticed changes in what are called colorless glasses, from light colors approaching white, to yellow and pink or purple. I have noticed also a change in a few specimens from a light green to a bluish shade. The former may be accounted for by the presence of manganese, a very minute proportion of which oxyd will have a sensible decolorizing effect in a crucible of melted glass metal. Pelouze's theory of the peroxydation of the iron may have some weight in determination of the cause of the yellow or pink color by the action of sunlight. But I know not how to account for the change of one specimen each of plate, crown, and sheet glass in my possession, from a greenish white to a bluih tinge, not mingled with either yellow or purple.

I have been pleased to find the interest in these experiments by photographers, who have long noticed that they could take better pictures under a newly glazed skylight, than under one which had long been exposed to sunlight. The cause of this change is, that the slightest yellow color interferes with the transmission of the actinic rays, and a very deep shade will cut them off in a very great degree. My experiments with glasses under other glasses proved which was best for photographers' use, information which all can gain by exposure of the specimens of various manufacturers which may be offered them. The most pure glasses of light green, or bluish white color are the best for photographers, and when I say *pure* glasses, I mean those most free from oxyd of iron or manganese, but especially of the latter, which, I think, is the cause of nearly all the changes which I have observed. Mr. J. W. Osborne, of New York, the gentleman who has done so much to bring the art of photo-lithography to perfection, and into practical use, writes as follows:

"I believe your researches will prove of much practical importance, and I wish the glass manufacturers could be got to give serious attention to the subject. It takes but a very slight tinge of yellow to cut off twenty-five per cent of the actinic rays. I am forced to work under glass, because of the protection from the wind and weather, but in doing so, I sacrifice in any case much of the light. I have to increase the time of exposure proportionately. With the best of glass, the loss from reflection and absorption is considerable. This may be fearfully increased by the color, and if that undergoes a continual change for the

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worse, the state of things is exceedingly unpleasant. I was warned by a photographic friend in England, to take care of a certain kind of cheap French glass, made for glass rooms, which turned yellow; but I had no notion that the evil was so general as you appear to have found it. The subject is of such vital importance to photographers, that I intend drawing the attention of that friend to what you have done."

I am indebted to Mr. Osborne for bringing our researches to the notice of his friends at home and abroad, who have contributed interesting articles and valuable information on the subject to the Philadelphia Photographer, (October, 1866,) the London Photographic News, (August 2, 1866,) the London Photographic Journal (Aug. 15, 1866,) and the Photographische Mittheilungen (Sept. 1866).

It may seem singular that so long an experience in the window glass business, had not at an earlier period drawn my attention to the subject of this article. But my experience is not singular. In conversation with many glaziers and glass dealers, I have seldom found one who was aware of the great change of color effected by sunlight. Few have supposed that specimens were to be found in any other windows in our city, than those on Beacon street facing Boston Common and the south, and exposed to the full force of the sun's rays. But having my attention now particularly directed to the subject, I never pass a window without detecting where any considerable change has been effected. I have found them in all portions of the city, and most generally in those positions which face the east and south. The color is most easily detected, when the glass has been ground or enamelled, or where a white window curtain forms a good contrasting back ground. Many people suppose that the very distinctly marked purple plate glass in Beacon st. was imported of this color, and that it is now no longer made; and hence the reason why the windows looked like checkerboards, when broken lights were replaced by those of the usual light greenish color of plate glass.

On this point I have convinced many who had held contrary views, by showing pieces from which the putty on the edges has been removed, and displaying beneath the original color. When the putty covered the glass, the sun's rays could not reach it, and the color was unchanged. Such specimens are quite interesting. I have had many conversations with old glaziers, dealers and consumers of glass, and also with those who stain and enamel it. I have thus gathered specimens of various kinds and colors, and of differing lengths of exposure from old windows. The oldest specimen was one of crown glass set in a church in Lexington, Massachusetts, in 1794, from which the windows were removed in 1846, and since used as covers for hot-beds. The

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original color, found by removing the putty from the edges, was a light green, and the present, after seventy-three years exposure, is a purple color. I have never yet met any one who has seen glass in original imported packages, of the purple color made by exposure to sunlight, and until I do, I shall adhere to my opinion, that all purple or rose colored glass which is seen in our city windows, was made so by said exposure. I have very fortunately found an octogenarian, who has furnished me with some glass which was imported, he thinks from some part of Germany, which is of a light green or yellowish green color. The glass was imported more than thirty years ago. Much of that which has been set in his windows facing the south is now purple. An experiment with the original glass, commenced this summer, showed a perceptible change in color in one day, and in two weeks, the change toward purple was so marked that I have no doubt that this color will be distinctly visible in less than a year. If two years were occupied in the erection of the Beacon street houses, or any others in which the plate glass purpled by sunlight is found (as I am informed was the fact in some cases), then the result of the single experiment named above is a sufficient reason for the mistaken belief of many occupants and owners to-day, that the glass was purple when imported. It was probably changed from yellowish green to purple before the houses were finished, and the owners had taken possession.

The action of sunlight which I have spoken of in this article, must not be confounded with that called "rust" or "stain," which is occasioned by exposure to the weather, and manifests itself in two ways; first, by a disintegration and roughening of the surface, sometimes producing all the effects of ground glass; and secondly, by an apparent formation of an infinitesimal coating of oxyd on the surface, on which the play of light gives all the colors of the rainbow, as with the action of light on the infinitesimal grooves of the surface of mother-of-pearl. This is simply surface action, whereas the action of sunlight permeates the whole body of the glass, wherever the rays directly strike it.

The writer of this article, (compiled in the midst of the busy duties of mercantile and official life,) makes no pretension to accurate scientific knowledge, but gives the results of his observations and methodical experiments on a well known phenomenon, in the hopes that they may add some mite to the sum of human knowledge, and may stimulate and aid those who are better versed in scientific studies, to ascertain the causes and exact operations of this interesting power of the sun's rays to paint the products of art, as they do so beautifully and wonderfully the works of nature on the mountain, in the forest and field.

Boston, Mass., July, 1867.

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ART. XXXIV.—*Remarks on Prof. Geinitz's views respecting the Upper Paleozoic rocks and Fossils of Southeastern Nebraska;* by F. B. MEEK.

[Concluded from p. 187.]

AFTER preparing the remarks published in the last number of this Journal on the Nebraska fossils figured and discribed by Prof. Geinitz, I had an opportunity, through an incidental connection as Paleontologist, with the Nebraska Geological Survey (in charge of Dr. Hayden, under the direction of the Hon. Commissioner of the General Land Office), to devote about two months to field explorations in the Coal-measures of that region. In order to trace out as fully as possible, the order of succession of the various beds of the whole series, our observations commenced with the Subcarboniferous, and Lower Coal-measure rocks on Desmoines river, Iowa. Over two weeks were thus occupied with Dr. White, the able State Geologist of Iowa, and his efficient assistant, Mr. St. John, accompanied by Dr. Gill of Washington, D. C., in an overland journey from Iowa City, Iowa, westward to Nebraska City, Nebraska.

The remainder of the time was mainly spent with Dr. Hayden and party, in studying the Coal-measure rocks along the Missouri from Omaha, Nebraska, down to Kansas, and in excursions into the interior, including a journey out the Union Pacific Rail Road to its terminus, at that time within five miles of the northeast corner of Colorado. A short time was also devoted to investigating the Coal-measures in the environs of Sumner and Atchison, Kansas, and St. Joseph, Missouri, with Mr. Scarborough, a scientific gentleman of the first mentioned place.*

During these explorations, numerous natural sections, shafts, drifts, quarries, borings, and excavations of various kinds were carefully examined, and large collections of fossils and other specimens obtained. It would of course be out of place here, if I had the authority to do so, to attempt even a general sketch of the results of these explorations.† I am permitted, however, to mention a few of the facts observed, having a bearing on the question in regard to the age of the rocks at and near Nebraska City, referred by Prof. Marcou and Prof. Geinitz to the Permian.

In the first place, it may be well to give a few additional items of information in regard to some of the fossils figured by Prof.

* Our examinations in Iowa and Nebraska, excepting the excursion out the Pacific Rail Road, were made while traveling by land, in wagons or on horse-back, provided with assistants and the necessary fixtures for camping, wherever we wished to stop.

† The facts observed in Iowa will be published in the Report of Dr. White to the proper State authorities; and the results of the observations in Nebraska, in Dr. Hayden's official Report to the Hon. Commissioner of the General Land Office.

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Geinitz, from this region, in part mentioned in my remarks published in the last number of the Journal. For convenience, in doing so, I will use the names by which he has designated them, as follows:—

Cyathaxonia, taf. v, f. 3. This form from Plattsmouth, compared by Prof. Geinitz, *C. tortuosa* Mich., is the same described by McChesney from the western Coal-measures under the name *C. prolifera*. The other represented by fig. 4, of the same plate from Nebraska City, is probably only a variety of the same. At any rate Dr. Hayden found well-marked examples of the *C. prolifera* in bed B at Nebraska City, that cannot be distinguished on direct comparison with authentic specimens of that species from the typical localities in Illinois.

Allorisma elegans King. The shell figured under this name is certainly a distinct species, and not a *variety* of the *elegans*, since a fine series of specimens show it to be *exceedingly* constant in all its characters (which are well represented in Prof. Geinitz's figure), while it differs from that species not only in never attaining one-tenth the size of larger examples of that shell, but in being much narrower and more distinctly truncated behind, as well as in having its umbonal slopes *always* sharply keeled. Its umbones are also more elevated.

Schizodus Rossicus de Vern. As nearly as the little shell referred by Prof. Geinitz to this species resembles the published figures of *S. Rossicus*, a direct comparison shows it to be quite as closely allied to *S. curta* of Meek and Worthen, from the Coal-measures of Illinois, and Atchison, Kansas.* It agrees exactly in size, and all other known characters with the *S. curta* excepting that it is a little more compressed, and has slightly less elevated beaks. On comparison with the figures of *S. Rossicus* given in the geology of Russia, the Nebraska shell is found to have its anterior ventral region *constantly* more prominent and rounded, and its posterior margin more distinctly, and more nearly vertically truncated, so as to give more angularity to the posterior ventral extremity, as is well represented by Prof. Geinitz's figures. It is possible these differences may be only due to a want of care in the artist, in drawing the Russian shell; otherwise I should not hesitate to regard the Nebraska form, that from Illinois, and those figured from Russia, as three closely allied, but distinct species. That under consideration is exceedingly constant in all its characters (as shown in a good series of specimens) and exhibits no tendency to the variations of form said to be presented amongst the different individuals of *S. Rossicus*.

* The beds at Atchison, Kansas, hold a lower stratigraphical position than the rocks above the mouth of Platte river, referred by Prof. Marcou to the Mountain limestone.

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Aucella Hausmanni Goldf. In the last number of this Journal, I expressed the opinion that the form figured under this name, is the same as *Myalina Swallovi*, so common in the western Coal-measures. This conclusion is strengthened by the occurrence of well marked examples of the *S. Swallovi* in the collections before me from Prof. Marcou's bed C, at Nebraska City; while no other similar form was found there or elsewhere in these rocks. On the other hand, the casts figured by Prof. Geinitz (from the Permian of Kansas and not from Nebraska) under the name *Myalina perattenuata*, and which I had supposed to belong to that species, must be the *M. permiana* of Swallow, though they have more attenuate beaks than is common in that species. The two forms, however, are very similar, and in some of their varieties can not be readily distinguished, as has been ascertained from comparison of specimens recently obtained by Dr. Hayden. The typical *M. permiana* does not occur, so far as known, on the Missouri.

Spirifer laminosus McCoy. The species figured by Prof. Geinitz under this name, is, as already stated, the common and widely distributed *S. Kentuckensis* of Shumard. In the last number of this Journal, I expressed the opinion that it would probably be found to be a true *Spiriferina*, an opinion I believe also entertained by Dr. Shumard. On recently examining several examples from Nebraska City, and other localities in Nebraska, Iowa and Kansas, I find that they not only show under the microscope the punctate structure, but that they also possess the internal plate of *Spiriferina*. It is an extremely variable shell in the convexity of its valves, as well as in the proportional length of its hinge line. The more ventricose varieties with a short hinge, are sometimes very similar to *S. octoplicata* Sowerby, to which indeed the species has been referred in Stansbury's Salt Lake Report. The individual figured by Prof. Geinitz is a compressed variety (its compression however is *partly* due to accidental pressure) with an extended hinge, and shows a small plication in the mesial sinus not often seen so well developed, though occasionally present. The specimens collected by us at Nebraska City, include all the varieties assumed by this shell at other localities in the Coal-measures.

Lima retifera Shumard. Fine specimens of the shell referred to this species by Prof. Geinitz, were obtained by us in the division C at Nebraska City, and they agree well with Dr. Shumard's description. The type specimens first described by Dr. S., it will be remembered, were found in Kansas in the Coal-measures associated with *Fusulina cylindrica* and *Productus Nebrascensis*.

Stenopora columnaris Schlot (sp.) Specimens from the divisions B and C at Nebraska City, as well as from various lower

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positions in the Coal-measures at other localities, agree more or less nearly with some of the supposed varieties figured under this name by Prof. Geinitz in his work on the German Permian fossils. If that species, however, which according to Prof. G. occurs both in the Permian and Carboniferous of the old world, varies to the extent necessary to include all the forms cited in his synonomy, it would appear difficult to determine the extent of its variations, or its geological range.

Synocladia virgulacea (Geinitz, not Phillips; properly *S. biserialis* Swallow). Good examples of this species from division C at Nebraska City, show that the little prominences along the mesial carina of the celluliferous side of the branches, are not generally so elevated as to be properly called even *short* spines. The species, however, differs from *S. virgulacea*, as illustrated and described by King, as already stated, in having properly but two rows of cellules to each branch, instead of from three to five. Nor are these cellules ranged in longitudinal furrows as in *S. virgulacea.* In some instances, in the largest branches, there is an occasional odd cellule near the lateral margins, that cannot be properly regarded as belonging to either of the two rows, but these never form a third or fourth row as shown in *S. virgulacea.* Again, there is always on the Nebraska fossil a single *mesial* longitudinal ridge (usually having minute pores), on the celluliferous side, instead of two, with a mesial row of cells between.

Without going into farther details, I would state that with some two or three exceptions, the lately obtained collections from Nebraska City, and near there include all the species figured by Prof. Geinitz from the beds he refers to the Permian, together with a number of others not collected by Prof. Marcou; and that we now know nearly all these fossils (excepting some seven or eight new species not yet found at any other locality) to be common to these supposed Permian beds and the Coal-measures of Iowa, Illinois, Kansas and Nebraska, where they occur in and beneath, as well as above the very beds referred by Prof. Marcou and Prof. Geinitz, to the Mountain limestone near and above the mouth of Platte river, on the Missouri. In regard to the 7 or 8 new species yet only known from Nebraska City, it may be proper to remark, that with two or three exceptions they are all as nearly allied to Carboniferous as to Permian forms.

In addition to the species figured by Prof. Geinitz, we now know the following other Carboniferous fossils not found here by Prof. Marcou, to occur in the beds he refers to the Upper Dyas at Nebraska City and near there, viz: *Fusulina cylindrica* Fischer, *Terebratula bovidens* Morton, *Orthis carbonaria* Swallow, *Retzia punctulifera* Shumard (=*Terebratula Mormonii* Marcou),*

* Prof. Marcou mentioned finding this at Nebraska City, but Prof. Geinitz does not enumerate it amongst the Nebraska City species, but gives Plattsmouth as the locality. It occurs at both places however.

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Pecten aviculatus Swallow, (not a true *Pecten*), *Aviculopecten Coxanus* M. & W., *Aviculopecten*, sp. undetermined (common in the Coal-measures of Iowa), and *Pinna peracuta* Shumard; also the following Carboniferous types of fishes, viz: *Ctenoptychius semicircularis* Newberry and Worthen, *Cladodus mortifer* N. & W., *Antliodus* and *Chomatodus* of undetermined species, and another form nearly allied to, or identical with *Deltodus*. We likewise found a fine tooth of *Petalodus destructor* N. & W., so characteristic of the Illinois Coal-measures (referred by Prof. Marcou to the Mountain limestone), in the same beds at Rock-bluff included by him as a part of the Lower Dyas.

It will therefore be seen, that in addition to nearly all of our common Coal-measure *species* of other animal remains, we now know from these supposed Permian rocks of Nebraska and Iowa, the following *genera*, believed to be either exclusively Carboniferous, or not known above the Coal-measures, viz: *Fusulina*, *Erisocrinus*, *Bellerophon*, *Phillipsia*, *Petalodus*, *Cladodus*, *Ctenoptychius*, *Chomatodus*, *Antliodus* and *Cochliodus*; while not a single trace of any peculiarly Permian type of fishes, has ever been found in these rocks.

But it may be proper to mention more precisely the localities and positions at which these Carboniferous types were discovered. In the first place we would state that we found *Fusulina cylindrica* in vast numbers along with nearly all our Coal-measure species at Rock-bluff in the very beds referred by Prof. Marcou to the Lower Dyas. We likewise found this fossil in great numbers 2¾ miles west, and less abundantly at Mr. Morton's place 1¾ west of the Nebraska City landing, associated with the same Coal-measure species, at the elevation of 75 to 80 feet above low water mark of the Missouri; also at Wyoming, 7 miles north, and at Bennett's mill, 3 miles northwest of Nebraska City, all in the same beds referred by Prof. Marcou to the lower part of the Upper Dyas.* *Terebratula bovidens*, *Orthis carbonaria*, *Retzia punctulifera*, *Pinna peracuta*, *Cladodus mortifer*, teeth of *Antliodus* and *Deltodus?* were all found at Nebraska City in division B of Prof. Marcou's section (the last two by Dr. White of Iowa).

The teeth of *Ctenoptychius semicircularis* were found, one in a shaft at Nebraska City, at near the horizon of Prof. Marcou's division B; another at that horizon by Dr. White at Bennett's mill, and another by the same gentleman at Omaha, in beds referred by Prof. M. to the Mountain limestone. We also found it in beds he referred to the latter horizon at Bellevue. The *Chomadotus* was found by Mr. St. John of the Iowa survey, in the so-called Upper Dyas at Bennett's mill. The same *Phillipsia* figured by Prof. Geinitz from Plattsmouth, and a tooth of a *Cochliodus* have

* *Fusulina* and other carb. fossils, also occur in an 18 inch bed of limestone one mile below the outcrop at Nebraska City landing, and at a higher geological horizon.

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been found in Iowa by Dr. White, in limestone above the horizon of beds containing the same group of fossils characterizing Prof. Marcou's division C at Nebraska City; while *Pecten aviculatus*, and *Aviculopecten Coxanus*, were found in that bed at the last mentioned locality.

From all the foregoing facts, it will be seen, that I am compelled to dissent from the conclusions adopted by Prof. Geinitz, not only in regard to the relations of many of the Nebraska fossils investigated by him to the European Permian species to which he has referred them, but also respecting the age of the rocks from which they were obtained. Of the various species he identifies with foreign Permian forms, there are, it seems to me, not more than some four or five that are so closely similar that no very satisfactory distinction can be detected, from external characters at least. These are the forms he refers to *Nucula Beyrichi*, *Leda Kazanensis*, *Schizodus Rossicus*, *Avicula spelunca*ria,*=(*Pseudomonotis*), and *Pleurophorus Pallasi*. The first four of these are, I acknowledge, very similar to the Permian species to which he has referred them, while the fifth seems to be as nearly like *Pleurophorus costatus*. The fact, however, that we know comparatively little of the hinge and interior of these shells, while they are mainly such forms as often present few reliable external characters for specific distinction, and belong for the most part, to genera in which the species are frequently very similar, must weaken our confidence in these specific identifications, under such circumstances. But when we take into consideration the additional fact, that they can all be identified upon quite as good grounds with forms found far down in beds acknowledged by all to belong the Coal-measures, or which have even at some places been referred by Prof. Marcou to the Mountain limestone, and especially when we bear in mind, the numerous unquestionably Carboniferous types with which they are here directly associated in the beds under consideration, the impropriety of basing important conclusions upon them must be apparent.

It may be urged, however, that with the aid of extensive collections of European Permian species for comparison, Prof. Geinitz has had far better facilities for arriving at correct conclusions, in regard to the relations of all of these Nebraska fossils to foreign forms, than can be commanded here. Granting this to be to a considerable extent true (for I have had for comparison a tolerable collection of the more common European Permian species), I must still contend—with all due deference to his deservedly high standing as a geologist—that his peculiar views in

* The species figured by Prof. Geinitz under this name as elsewhere stated, came from the Permian of Kansas and was not found in Nebraska. He refers to that species, however, specimens from Nebraska City, doubtless the same form we saw at Bennett's mills, and evidently very closely allied to the species *Spelunca*ria.

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regard to specific and generic distinctions, are such as to materially detract from the value of his paleontological conclusions in a case like that under consideration. The fact that he has unquestionably identified *specifically*, with European forms, several Nebraská fossils belonging to entirely different genera, and in some instances different families, shows conclusively, that if he has kept pace with the recent advances made in conchology and other departments of natural history, he has not, in this instance at least, brought to bear that degree of exactness of discrimination the present state of zoological science shows to be absolutely necessary, before we can hope to arrive at sound conclusions in paleontology.

The necessity for great care in identifying species and genera of shells, has of late years been forcibly illustrated by various anatomical researches, but particularly by the results of the valuable investigations of the lingual dentition of the *Gasteropoda*, made by Loven, Troschel, and others, in Europe, and Dr. Stimpson, Mr. Morse, and others, in this country, by which means forms long regarded as specifically identical have been found to be quite distinct, and so in regard to the genera and higher groups. A case, however, coming more directly home to paleontologists and geologists, is that in which recent microscopical investigations have rendered it probable that a form, until very recently regarded by the highest living authorities as the common *Spirifer cuspidatus* of Sowerby, is not only specifically, but even generically or subgenerically distinct.*

Yet the question may naturally suggest itself, whether, if we admit that only a very few, or even none, of these Nebraska fossils are *absolutely* identical with European Permian *species*, the near affinities of a portion of them to foreign species of that epoch, ought not to be regarded as a sufficient evidence of the contemporaneous age of the rocks from which these were obtained, with those of the Permian of the old world. At a first glance, looking at these Permian types† only, this would certainly seem to be a logical conclusion; and reasoning upon evidence of this kind, Dr. Hayden and the writer actually referred some of these beds on the Missouri to the Permian in 1858, (Trans. Albany Inst., vol. iv.) On afterwards ascertaining, however, that a very large proportion of our most common and characteristic Coal-measure fossils occur in the same beds containing these few Permian types, while the latter, including the so-called *Monotis*, the Bakevellias, *Pleurophorus*, *Schizodus*, &c., are also occasionally met with far below, in unquestionable and acknowledged

* See Proceed. Acad. Nat. Sci. Philad., Dec. 1865, p. 27; this Journ., May, 1867, and Ann. and Mag. Nat. History for July, 1867.

† By Permian types, I mean forms closely allied to, but not necessarily identical with, Permian species.

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Coal-measure strata, we were led to doubt the accuracy of our first conclusion.

These doubts were afterwards confirmed, when on going out into the interior of Kansas, we found there an extensive series of strata, in no way separable from the Coal-measures, containing several of these and a few other Permian types, along with nearly all our common Coal-measure fossils, such as *Fusulina cylindrica*, *Productus longispinus?* (=*Productus Wabashensis* N. & P.), *P. punctatus*, *P. costatus*, *P. Nebrascensis* (=*P. horrescens* of Prof. Geintz's list), *Chonetes mucronata*, *Spirifer cameratus*, *S. planaconvexus*, *Syntrilasma hemiplicata*, *Streptorhynchus crenistria*, the so-called *Orthis Missouriensis*, *Athyris subtilita*, *Naticopsis Pricii*, *Euomphalus rugosus** (Hall not Sowerby), species of *Phillipsia*, and *Bellerophon*, *Petalodus Allegheniensis*, and numerous others that might be mentioned. These we found often mingled in the same beds with the few Permian types, and in other instances in beds alternating with those containing the latter. In ascending several hundred feet higher in the series, we observed the Coal-measure forms gradually dropping off until at last, above a certain undefined horizon, with the exception of one or two of the latter, only Permian forms were observed. Although we regarded these upper beds as the true representatives of the Permian, we gave a section of the whole series, down so as to include a considerable thickness of beds below, with lists of fossils, showing the range of the various types, without drawing any line of demarkation, because we were satisfied nature had no where defined any abrupt physical or paleontological break here in the series. We likewise stated that we believed no geologist, studying these rocks without a knowledge of the classification adopted in the old world, would ever have thought of making any important division here between the Permian and the Coal-measures; and that if the intermediate series containing a mingling of the two types of fossils is to be separated at all from the Coal-measures, we would do it only under some such provisional name as the Permo-carboniferous series.

It will be remembered by those who have read Prof. Marcou's paper on the rocks under consideration, (Bull. Soc. Geol. Fr., 2d ser., xxi, p. 132, 1864), that he referred the Nebraska City beds (including those at Bennett's mill and Wyoming) to the upper Dyas; those at Rock-bluff and Plattsmouth to the lower Dyas, and those above the Platte, at Bellvue, St. Mary's, and Omaha City (erroneously printed Omalia City), to the Mountain limestone. The outcrops at Plattsmouth and Rock-bluff, he thought, con-

* Since pointing out the differences between this and *Spirorbis planorbitis*, I observe Prof. Geinitz figures under the latter name, in his Dyas, one form with the greatest concavity apparently on the left, another with it on the right side. The quadrangular form of its whorls, and its flattened periphery, however, clearly separates our shell from both of these.

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tained the remains of an "eminently New Red Sandstone fauna, approaching, however, the Carboniferous fauna," (ibid, p. 140.)

After examining the fossils collected by Prof. Marcou from these beds, however, Prof. Geinitz refers 30 of the 36 forms composing this so-called "eminently new red fauna" to Carboniferous species, and thinks these rocks hold the position of the upper division of the Carboniferous limestone, or *Fusulina* limestone of Russia and Spain; while the outcrops of Rock-bluff, he thinks, may be considered an upper marine member of the productive coal formation. It is, therefore, only the Nebraska City beds, and those at Mr. Morton's, Bennett's mill and Wyoming, that he refers to the Dyas.

In not admitting the Plattsmouth and Rock-bluff exposures as belonging to the New Red, Prof. Geinitz certainly corrects a grave error of Prof. Marcou's; but if by the words "Carboniferous, or *Fusulina* limestone," he means to place these rocks on a parallel with any part of the Subcarboniferous or Mountain limestone series, as Prof. Marcou has done those above the mouth of the Platte, he falls into as great an error as that he corrects. The evidence of this statement is, the fact that the group of some thirty odd species of fossils found at these localities is *precisely* that characterizing the Coal-measures of Illinois, Iowa, Missouri, and Kansas, and with the exception of four or five species generally considered common to our Coal-measures and the Mountain limestone, they are *all* distinct from the fossils found in our Carboniferous limestones below the Millstone grit.* In addition to this, they are, with three or four exceptions, now known *all* to occur at Nebraska City, Bennett's mills, and Wyoming, in the very beds Prof. Geinitz considers Upper Dyas, along with other Coal-measure species.

It is probable Prof. Geinitz was mainly led to refer the Plattsmouth rocks to the horizon of the *Fusulina* limestone of Russia and Spain, by the occurrence in them of numerous *Fusulina*, and, as he terms it, "the leading genus *Phillipsia*;" since he acknowledges that a large proportion of the fossils found there also occur in the rock he refers to the Dyas. He was, therefore, evidently not aware of the fact that with nearly *all* of the Plattsmouth fossils, countless millions of *Fusulina* also occur in the Rock-bluff section, placed by him in the Coal-measures; as well as (excepting so far as regards the *numbers* of *Fusulina*) in the

* The following is a list of species known to occur in the Plattsmouth rocks, viz: *Fusulina cylindrica* (in great numbers), *Zeacrinus mucrospinus?*, *Cyathocrinus hemisphericus*, *Productus semireticulatus*, *P. Nebrascensis*, *P. costatus*, *P. Prattenianus*, *P. longispinus.?* *P. punctatus*, *Chonetes mucronatus*, *Streptorhynchus crenistria*, *Syntrilasma hemiplicata*, *Meekella striatocostata*, *Athyris subtilita*, *Rhynchonella Utah*, *Retzia punctulifera*, *Spirifer cameratus*, *Spirifer planoconvexus*, *Sp. lineatus?*, *Spiriferina Kentuckensis*, *Myalina subquadrata*, *M. ampla?*, *Pecten* (??) *aviculatus*, *Aviculopecten occidentalis*, *Pinna peracuta*, *Allorisma subcuneata*, *Bellerophon carbonaria*, *Euomphalus rugosus*, *Nautilus Illinoisensis?*, *Phillipsia* undet. sp.

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same beds he and Prof. Marcou include as the inferior member of the Upper Dyas near Nebraska City, at Wyoming and at Bennett's mill. He also ignores the fact, that Prof. Marcou mentions seeing in the Plattsmouth beds, a specimen of the so-called *Monotis** (*Pseudomonotis*), one of the most important types relied upon to prove the divison C, at Nebraska City, a part of the Dyas.† Nor does he appear to duly appreciate the fact that there is no *one* limestone in this country, that can be properly termed "the *Fusulina limestone*," for we have numerous *Fusulina* limestones, at various horizons through the whole Coal-measures of Iowa, Missouri, Nebraska and Kansas; while Dr. White finds it and the genus *Phillipsia*, in Iowa, above beds containing the same groups of fossils characterizing the division C at Nebraska City, referred by Prof. Marcou to the Upper Dyas.

Again, in speaking of the Rock-bluff beds as a "*marine* member of the upper productive Coal-measures," Prof. Geinitz seems not to be aware of the fact, that the whole of our western Coal-measures abound in marine fossils, there being no member of our entire Paleozoic series containing a greater profusion of marine types of fossils than the Coal-measures of Nebraska, Kansas, Iowa, Missouri, Illinois, Kentucky, &c. Had he fully understood all of these facts, and the true relations to each other, and to the other Carboniferous rocks in this country, of the several outcrops from which the fossils submitted to him were obtained, there can be no doubt whatever, but he would have arrived at different conclusions from those adopted by him, respecting the age of these rocks, if not in several instances respecting the specific relations of the fossils themselves, to European Permian forms.

After a thorough revision of the whole subject, and a personal examination of all of the exposures mentioned by Prof. Marcou, and numerous others in Iowa, Nebraska and Kansas, not visited by him; as well as after a careful study of extensive additional collections of fossils from these rocks over wide areas, I have no hesitation in reasserting, that all the rocks above the mouth of Platte river referred by Prof. Marcou to the Mountain limestone, and those of Plattsmouth and Rock-bluff placed by him as Lower Dyas, and by Prof. Geinitz, in part on the horizon of the Upper member of the Mountain limestone, and in part in the Upper Coal-measures, as well as those by both of them referred to the Upper Dyas at Wyoming and Bennett's mill and Nebraska City, with *possibly* the exception of divisions C and D at the latter place, belong to the horizon of the Upper Coal-measures. The only point in regard to which there can be any reasonable doubt is, whether the divisions C and D at Nebraska City, belong more prop-

* Bull. Soc. Geol. Fr., II, xxi, 139.

† It is well known to occur at even much lower horizons in Kansas.

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erly to the horizon of the rocks Dr. Hayden and I termed Permo-carboniferous in Kansas, or to the Coal-measures proper. Or, whether in case it is decided that we *must* draw an arbitrary line somewhere in this region, directly between the Coal-measures and Permian, it may not be thought most consonant with the range of types here to bring down this line, in spite, so to speak, of the various acknowledged Carboniferous forms found in these beds, so as to include the divisions C and D in the Permian.

The great objection however, to the adoption of the latter conclusion, is not only the occurrence of so many unquestionable Carboniferous species in the bed C, at Nebraska City, but the fact that nearly the whole group of fossils found in this bed C at that place, including most of the Permian types, such as the so-called *Avicula speluncaria*, *A. pinnaeformis*, *Schizodus*, *Bakevellia*, *Pleurophorus*, *Leda*, *Nucula*, *Cythere*, &c., also occur in Iowa, beneath others containing nearly all of our most common and characteristic Upper Coal-measure types, and indeed beneath heavy beds of limestone, agreeing in lithological characters, and containing the same groups of fossils found in those on the Missouri referred by Prof. Marcou to the Mountain limestone, as has already been determined by Dr. White (see this Journal, July, 1867, p. 28.)* During my late excursion to the west I had the pleasure of visiting, with that gentleman, some of these localities in Iowa. At one place in Union county, we found directly overlying a bed containing the fossils characterizing division C at Nebraska City, a black fissile shale, containing several specimens of *Aviculopecten rectilaterrea* (*Avicula rectalaterarea* Cox), a species which in Kentucky characterizes the horizon of the ninth coal bed of that State. Immediately above this black shale, in a decomposing limestone with marly partings, we found *Fusulina cylindrica* Fischer, *Spirifer cameratus* Morton, *Spirifer Urii* Flem., *S. planoconvexus* and *Spiriferina Kentuckensis* Shumard, *Orthis carbonaria* Swallow, *Productus Nebrascensis* Owen, *P. longispinus* Sowerby?, *Chonetes Verneuiliana* N. & P., *Streptorhynchus crenistriata*, *Naticopsis Wheeleri* (=*Littorina Wheeleri* Swallow, a species scarcely distinguishable from *Natica mariæ* M. V. & K., from the Carboniferous rocks of Russia), and the same little *Phillipsia* figured by Prof. Geinitz from Plattsmouth.

At other places in the same region in Iowa, Dr. White has found in the limestones and other beds holding a still higher position, nearly all of the above fossils, and many other Carboniferous types, such as *Meekella striato-costata* (*Plicatula striato-costata* Cox), *Myalina subquadrata* Shumard, *Productus costatus*, *Athyris subtilita*, and numerous *Fusulina*, with teeth of *Cochlio-*

* It is also well known that in Kansas, beds containing a similar mingling of Permian and Carboniferous types of fossils alternate with others containing almost exclusively Carboniferous forms, through a considerable thickness of strata.

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dus, &c. Indeed, Dr. White has already shown that the beds in Iowa, containing the group of fossils found in the division C, at Nebraska City, hold a position about the middle of the Upper Coal-measures in that State (see this Journal for July, 1867.)

I may also add, that our examinations through Iowa, fully and completely confirm Dr. White's statement, that no Subcarboniferous rocks are met with after leaving the outcrops seen along the Desmoines river, in going westward all the way to the Missouri nor along the Missouri, in that State; all this intermediate country being occupied by Coal-measures, excepting some insignificant patches of Cretaceous sandstone. I am aware Prof. Marcou has expressed the opinion that all of the Coal-measures of Iowa, Missouri, Illinois, &c., really belong to the horizon of the Mountain limestone. I can only say, however, that this is done in the face of the indisputable facts, that the fossils of these rocks in Iowa, Nebraska, Kansas and Missouri, differ, as already stated, almost entirely from those of our Subcarboniferous rocks, as every one in this country knows; and agree exactly with what he calls an "eminently new red fauna" at Plattsmouth, while the Coal-measures of Illinois, containing the same fauna characterizing those of the other States named, can be traced without interruption to the southern boundaries of that State, and also into Kentucky, where they are separated from the Subcarboniferous rocks, by from fifty to three hundred or more feet of Millstone grit. In addition to this, it is now generally known that Lesquereux has found the flora of the Coal-measures of Illinois, Kentucky and Indiana, to agree with remarkable exactness, so far as the identity and similarity of species are concerned, with that of the true Coal-measures of Europe.

Indeed, so thoroughly have our western Carboniferous rocks been studied of late years, during the progress of the several State geological surveys; and so completely are the order of succession, thickness, characteristic fossils, &c., of their various subdivisions known, that almost any amateur collector in these districts can instantly decide, from a few corals, crinoids or shells, whether they came from a horizon above or below the Millstone grit. In fact, in a very great majority of cases, a single species would be sufficient to decide this question.

In short, all the facts presented by Prof. Geinitz and Prof. Marcou, when explained by what is known in regard to the geological structure of the country in western Iowa, eastern Kansas, and other neighboring districts of the west, exactly coincide with, and confirm the views published by Dr. Hayden and myself in 1858. That is, that there is in this region, a gradual shading off from an upper Coal-measure to a Permian fauna, through a considerable thickness of strata, forming a somewhat intermediate group which we called the Permo-carboniferous

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series; also that there is no defined break between this intermediate series, and the Permian above, or the Coal-measures below. Indeed all the phenomena here indicate a gradual change of physical conditions which had probably so nearly approximated those of the Permian in this region, long before the proper close of the Coal-measure period, as to favor the introduction, at certain localities, of some Permian types; while these changes and those following them for a long period of time, running through the interval between the close of the Carboniferous period and the true beginning of the Permian in other parts of the world, where the series seems to be separable into two distinct groups, were not so great as to materially affect the Carboniferous fauna.

Under such circumstances, it must be evident, that all attempts to correlate particular unimportant beds here, with minor subdivisions adopted in Europe, where a different state of things obtained, must necessarily fail; while different opinions will doubtless long exist in regard to the exact horizon in the intermediate series, where the line should be drawn here between the Coal-measures and the Permian. Possibly after much more extensive collections of fossils have been obtained from these rocks, and the vertical range of all of the species has been approximately determined, some more definite conclusions on this point may be arrived at from the percentage of species known to cross certain lines. It is probable, however, that even by this method, the line of division would be found shifting according to the particular parts of the field in which the comparison might be made, for it is evident as we follow the very same beds westward from Iowa and Illinois into Kansas and Nebraska, that the proportion of what would be called Permian types, is found to increase.

In conclusion, I would state, that I hope sometime to have the pleaure of seeing Prof. Geinitz in this country, and of accompanying him to these distant western localities; and although we would doubtless continue to differ upon minor points as to generic and specific distinctions of fossils, I am sure it would not take long to convince so able a geologist as he undoubtedly is, that there is no Mountain limestone within probably more than one thousand feet of the surface on the Missouri in eastern Nebraska, or western Iowa; and that all the rocks referred by Prof. Marcou and himself there to the Subcarboniferous, as well as all they referred to the Permian or Dyas, with *possibly* the exception already alluded to, belong to the Coal-measures.

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ART. XXXV.—*Indian Summer;* by JOSEPH E. WILLET, Prof. of Natural Philosophy and Chemistry in Mercer University, Georgia.

A PERIOD of several weeks in Autumn, characterized by smoky atmosphere, equable temperature and cloudless sky, has been known in America as Indian Summer. Several hints as to the cause of this phenomena have been thrown out, but no one of them seems to have been accepted as a sufficient explanation of the facts. The following views have been entertained by the writer for several years, and are presented for the purpose of attracting attention to the subject, with the hope that materials may be collected by observers, the discussion of which may lead to a true theory of Indian Summer.

First, as to the facts.

1. Indian Summer is not confined to North America, but occurs in both hemispheres.

It it so well known in the United States, that no reference need be made to its occurrence here. It is remarkable, however, that it extends on this continent, to very high latitudes.

Sir John Richardson passed the winter of 1848–9 at Fort Confidence, on Great Bear Lake, lat. 66° 54′ N. He remarks,* "with regard to the progress of the seasons, the 'Indian Summer,' as it is called, brought us three weeks of fine weather after our arrival in September."

Kaemtz, in his discussion of the height of the barometer in different seasons, says,† "In the autumn, on the contrary, when the air comes from the south, the south winds predominate; they pour upon the south of Eupope the water with which they are charged, and reach us perfectly dry; hence the beautiful weather, that sometimes prevails in the middle of autumn, and which is known in France under the name of *St. Martin's Summer;* in Germany it is called *the summer of old men*; and in North America, *the Indian Summer.*"

Dr. Livingstone, in his Travels and Researches in South Africa, page 537, when he had arrived at Gonye, lat. 16° 38′ 50″ S., says: "Aug. 22. This is the end of winter. * * * * The whole scenery is lovely, though the atmosphere is murky in consequence of the continuance of the smoky tinge of winter. This peculiar tinge of the atmosphere was observed every winter at Kolobeng," (lat. 24° 30′ S.) "but it was not so observable in Londa as in the south, though I had always considered that it was owing to the extensive burnings of the grass, in which hundreds of miles of pasturage are annually consumed. As the

* Richardson's Arctic Expedition in search of Sir John Franklin, p. 297.
† Complete Course of Meteorology, by L. F. Kaemtz, London, 1845, p. 283.

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quantity burned in the north is very much greater than in the south, and the smoky tinge of winter was not observed, some other explanation than these burnings must be sought for. I have sometimes imagined that the lowering of the temperature in winter rendered the vapor in the upper current of air visible and imparted this hazy appearance."

Lieut. J. M. Gilliss, in his very interesting work on Chili,* says, "All through March, and the larger half of April, unexceptionably fine weather lasts, though the atmosphere is less transparent by day than during the other seasons, and copious dews at night show its increasing relative humidity. About the close of the former month, or in the first half of the latter, there are usually from ten to fifteen days when it assumes that peculiar appearance between smoke and dry fog which is so notable as the "Indian Summer" of North America. During its continuance there is scarcely any wind; and, as the temperature after noon rises to summer heat, with its fresh southerly breeze, the air is more enervating than at the latter season. Here the resemblance between the two hemispheres ceases. Unlike the North American "Indian Snmmer," of which, its continuity once broken, there is no return until the following year, the Chilain "verano de San Juan,"† is often interrupted by a renewal of the periodic winds with greater force, or by clouds; and after a day or two, there succeeds another interval, when the air is tranquil and smoky."

In these extracts, we have evidence of Indian Summer in North America, Europe, Africa and South America.

2. Moreover, the indications are, that Indian Summer is a phenomenon of the temperate zone.

I have seen no allusions to it in the writings of travelers in arctic and tropical regions.

As we have seen above, it is distinctly marked in the United States, in Middle Europe, at Santiago in Chili, lat. 33° 26′ 26″ S., and at Kolobeng in South Africa, lat. 24° 30′ S., all within the temperate zone. Sir John Richardson, however, noticed it at lat. 66° 54′ N., just beyond the Arctic Circle, and Dr. Livingstone observed it at Gonye, lat. 16° 38′ 50″ S., about 7° within the torrid zone. The former can scarcely be regarded as an exceptional case, as the observation was made just beyond the Arctic Circle. The latter point is clearly within the torrid zone, but the remarks of Dr. Livingstone show its greater predominance in the temperate. He says "it was observed *every winter* at Kolobeng, (lat. 24° 30′ S.) but it was *not so observable* in Londa" (in which Gonye is situated) "as in the South," and

* The U. S. Naval Astronomical Expedition to the Southern Hemisphere, vol. i. Chile, page 90.

† St. John's Summer.

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that too, notwithstanding, the quantity (of grass) burned in the north (toward the equator) is very much greater than in the south" (toward the Antarctic). If the burnings of the grass were the cause of the smoky atmosphere, then the smokiness should have been more apparent toward the equator; whereas the reverse was so strikingly true, that he abandons his previous notions of a connection, between these burnings and the smokiness, of the nature of cause and effect.

3. The season when it appears and the period of continuance of Indian Summer seem, from the above, to be slightly different in different countries.

In North America, it occurs in September, October, or November in different years. It is sometimes confined to one well-defined period of two or three weeks, as at Fort Confidence, in Sept., and Oct., 1848. But more commonly it is extended through one-half or more of the autumn; presenting a series of smoky days, followed by a period of variable weather, to be restored again in full force for a short time, running thus interruptedly through two months or more. Kaemtz describes its season in middle Europe as "the middle of autumn," but says nothing of its duration.

In the southern hemisphere, Dr. Livingstone recorded his single remark of smoky weather on August 22d, which, with the reversed seasons of that hemisphere, corresponds with our February, but goes on to say, that this peculiar tinge of the atmosphere was observed every *winter* at Kolobeng. This would locate the South African Indian Summer in June, July and August, corresponding to our December, January and February, which period is two or three months later than our Indian Summer. Lieut. Gilliss describes the Chilian Indian Summer as extending "through the close of March and the first half of April," which corresponds with our September and October. From his further description above and from the collection of his register below, the season appears to be more marked and decided than with us.

4. Another point worthy of remark, is that there are individual days of smoky weather, distributed through the whole year and undistinguishable from Indian Summer, in any particular except the time of duration. Were they prolonged for a week or two, we should have Indian Summer in nearly every month of the year, and the phenomenon would cease to be regarded as peculiarly autumnal.

At this place, lat. 33° 37′ N., I have noticed for several years, smoky days in every month, excepting about one month in winter and one in summer. The register by Lieut. A. W. Whipple, U. S. A., of Psychrometric and Climatological observations,* on

* Report of Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean. Senate. Vol. iv, appendix H.

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his survey across the western plains from Ft. Smith, Ark., to San Pedro, Cal., presents the same fact. During the several months mentioned below, the whole period of the survey, observations of "smoky," "smoky atmosphere" and "very smoky" are recorded on the following number of days.

1853.	No. of days	1854.	No. of days
Aug.	3	Jan.	1
Sept.	6	Feb.	1
Oct.	10	March	1
Nov.	5		
Dec.	3		

The register of Lieut. J. M. Gilliss at Santiago in Chili is still more conclusive; for no month, observed during the years 1850-1-2, is without "slightly smoky," "smoky" or "very smoky" days. The number of such days in each month will appear in the following table, which has been collected from the Meteorological Observations, vol. vi.

	1850.	1851.	1852.
Jan.	6	9	23
Feb.	7	8	24
March,	21	15	26
April,	18	6	16
May,	5	7	10
June,	4	4	4
July,	5	1	9
Aug.	3	4	9
Sept.	4	3	6
Oct.	2	3	
Nov.	2	2	
Dec.	2	6	

Of like character with these individual smoky days may be the "dry fog" described by Kaemtz, Meteorology, pp. 469-71, as "common in north and west Germany as well as in Holland" and in other parts of Europe. That of 1783 had remarkable intensity and "presented the following phenomena:—its thickness was such, that in some places objects at the distance of five kilometers (3 miles) could not be distinguished; they sometimes appeared blue or else surrounded with vapor. The sun appeared red, and without brilliancy, and could be gazed at in the middle of the day; at its rising and setting, it disappeared in the haze." The fog appeared on different days in different parts of Europe and Asia—at Copenhagen, May 29th; in France and Italy, from the 16th to the 18th of June; in Norway, June 22d; in Switzerland, June 23d; at Stockholm, June 24th; at Moscow, June 25th; toward the end of June in Syria; and the 1st of July in the Altai. In 1834, Kaemtz noticed others in May, July and August; the one of May seemed to be transferred from place to

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place by violent N. E. winds. In these countries (Germany and Holland) the dry fog is coincident with the burning of peat; when the air is dry, the smoke remains suspended in the atmosphere and may be carried away by the winds. The wind always blows from the direction of the peat bogs, when dry fog is manifested; and fogs have frequently been seen coming distinctly from the peat bogs." "The very thick dry fog of 1834 came partly from the combustion of peat, and partly from the fires for which this year was noted." "To the same cause, probably, may be attributed the particular aspect of the air in autumn. In the fine days, when the air is very dry, the air is less transparent; distant objects are not seen distinctly, they appear surrounded by a slight fog." "Can the dry fog of 1783, which was diffused over a great portion of Europe, be attributed to the same cause?" Popular superstition in Europe attributes to this "dry fog" "the disease of smut in corn, and diseases in vegetables generally," and "the predominance of the north winds which then prevail, and they say that it drives away rain and storms, and is a cause of cold."

The above description of "dry fog" accords very well with the appearance of many occasional smoky days in this country, which, if they occurred in autumn, would be styled Indian Summer. Relying upon the description alone, I am inclined to class them together. Kaemtz, also, in the description above, of "the particular aspect of the air in autumn," seems to allude to the German Indian Summer, and thus connects together the phenomena of dry fog and Indian Summer.

So much for the facts, let us now turn to the theory of Indian Summer.

Any theory, to be complete, must equally apply to these occasional smoky days, which are distributed throughout the year; for these present exactly the same characteristics, and are noted by observers, as Lieut. Whipple and Lieut. Gilliss, in precisely the same terms, as the groups of autumnal days, commonly called Indian Summer.

Without alluding to previous theories on the subject, I suggest the following:

1. The smokiness is produced by real smoke, proceeding from the ordinary fires employed in preparing food, etc., or from extraordinary fires in the burning of grass, brushwood, etc. This is an evident and a sufficient cause, and it is unphilosophical to seek for others, until this is shown to be inadequate to the given effect.

Moreover, Kaemtz, as above, plainly ascribes the smokiness of "dry fogs" to the smoke from peat bogs. What is more to the point, Prof. Henry, in allusion to "dry fogs," remarks;*

* Patent Office Report. Agriculture. 1858, pp. 458–9.

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"The nature of these fogs is now pretty well understood, and more refined observations, particularly with the microscope, have served to dissipate the mystery in which they were formerly enshrouded. When a portion of the air in which the fog exists is filtered, as it were, through water, and the substance which is retained, is examined by the microscope, it is found to consist of minute fragments, in some cases, of burnt plants, and in others of the ashes of volcanoes." "Samples of substances which have been collected from rain water and examined microscopically by Prof. Schaeffer, of Washington, at the request of the Smithsonian Institution, have been found to consist of portions of plants, which must have come from a great distance, since the species to which they belong are not found in abundance in the localities at which the specimens were obtained. It is highly probable that a portion of the smoke or fog-cloud produced by the burning of one of our western prairies is carried entirely across the eastern portion of the continent to the ocean." In reference to Indian Summer, Prof. Henry remarks, "Though the first announcement of the proposition by some of our earlier meteorologists, that the peculiar condition of the atmosphere known as Indian Summer might be produced by the burning of the prairies, was not thought worthy of any comment, yet the advance of science in revealing the facts I have stated, renders this hypothesis by no means unworthy of attention."

Although these extraordinary fires may furnish the smoke for extraordinary manifestations of smokiness as in "dry fog" or unusually dense Indian Summer, yet I think too little importance has been attached to the smoke from ordinary fires. Immense volumes of smoke ascend daily from these, and it is not improbable that the majority of smoky days derive their smokiness from these ordinary sources.

2. Atmospheric currents, subsiding from higher to lower regions, would produce smokiness by depressing the smoke, and by coming under greater pressure would become relatively dry, and would thus produce relative dryness and equableness of temperature during their continuance.

Every meteorologist has, doubtless desired an indicator or vane for descending currents. Can any be devised more sensitive than smoke? The direction of horizontal currents is constantly determined by the swaying wreaths of smoke from chimneys. If the rising columns of smoke remain suspended in the lower atmosphere and hang like a smoky veil over the whole landscape, why may not the phenomenon be referred to descending currents of air? Why not follow the indications of the vane? If the smoke bends toward the north, east, south, or west, we attribute it to a wind from the opposite quarter. If it

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bends toward the earth, why not attribute it to a current from above? Mainly from the fact, that we are less familiar with descending currents, and that from the want of an indicator, we know less of their habitudes.

3. This subsiding of atmospheric currents may occur at any time, when circumstances favor; but it will be most apparent, when a conjunction of circumstances render them continuous through a series of days, as in the autumn.

Hence smoky days may occur in every month of the year, and a succession of them is called Indian Summer—near the autumnal equinox, when the violent disturbing elements of summer heat and winter cold are at a minimum. The vernal equinox would seem to be equally favorable with the autumnal; but, in the former case, a hemisphere cooled by the winter's cold and heating up under the advancing warmth of the season may be less favorable to a stable equilibrium of the atmosphere, than the same hemisphere heated by summer and cooling by radiation during the autumn.

4. Descending currents of air are supposed to occur most in the temperate zones, and Indian Summer seems to be a phenomenon of the same zone.

Kaemtz seems to think that the trade winds return toward the poles as an upper current and settle to the earth about lat. 30° and thence flow as a surface current toward the poles, returning to the equator by some route not well indicated. American meteorologists* think that the atmosphere of a hemisphere is divided into three systems, with upper and lower currents, and with belts of rains or of calms where the systems meet. But all agree as to the descent of the upper currents, whether from the equator or from the poles, to a greater or less extent, over the temperate zone and these may, when other circumstances favor, depress the smoke and produce Indian Summer.

In the above discussion, I have attempted to show that Indian Summer, the occasional smoky days distributed throughout the year, and probably dry fog are similar if not identical phenomena, and attributable to the same cause; that the smokiness is due to ordinary smoke derived from the ordinary or extraordinary fires of a country; that the smoke is held suspended in the lower portions of the atmosphere by descending currents of air; and, finally, that the phenomena seem to prevail most in autumn and in the temperate zones, and the descending currents originate in the subsidence toward the earth of the upper currents from the equator or from the poles.

In conclusion, it is proper to say, that, by examination of the

* See an able paper on the subject by Prof. Henry, Patent Office Report. Agriculture, pp. 471–7. Also Maury's Physical Geography of the Sea. Also a paper by W. Farrel, this Journal, II, xxxi, No. 91.

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only complete register, that of Lieut. Gilliss, in my possession, I have not been able to connect the views here presented with the indications of the barometer. This was hardly to be hoped for, from a single register, at one locality.

Indian Summer prevails over a large extent of territory, and its laws must be evolved by the discussion of many registers kept at places distributed over the whole territory. Smokiness is rarely recorded by observers among the phases of the sky, and hence previous registers throw little light upon the subject. Should the attention of observers, hereafter, be directed to this phase, the mass of observations thus obtained may show whether the phenomena are simultaneous or consecutive over a large extent of country; whether the barometer rises or falls, &c.; and may elicit some law favorable or unfavorable to the views above suggested; but which will remove the mystery, which has so long hung around the subject of Indian Summer.

Penfield, Ga., August, 1867.

ART. XXXVI.—*A method of determining the amount of Protoxyd of Iron in Silicates not soluble in the ordinary mineral acids;* by JOSIAH P. COOKE, Jr.

THE accurate determination of the amounts of protoxyd and sesquioxyd of iron in siliceous minerals is a point of much importance in mineralogy, and when the silicate can be dissolved by the ordinary mineral acids, this determination presents no great difficulties. But it is very different with the so-called insoluble silicates. In regard to these the problem has never been satisfactorily solved; so that the exact condition of oxydation of the iron in some varieties of the most common species is not with certainty known. Many siliceous minerals which are not perfectly decomposed by the dilute mineral acids in an open vessel, are dissolved after long digestion in a sealed flask, and in a former paper the author described a simple and accurate method of determining the amount of protoxyd of iron in all silicates of this class. The method here described applies chiefly to the silicates, which cannot be thus decomposed and is based on the use of hydrofluoric acid as a mineral solvent. With a very few exceptions all silicates are dissolved after a more or less prolonged digestion in a mixture of sulphuric and hydrofluoric acids, and in this solution the amount of protoxyd of iron can be accurately determined with permanganate of potassa. It is of course essential that the solution should be made out of contact with the air and the difficulty of fulfilling this condition with hydrofluoric acid has probably been the reason why this valuable reagent has not been hitherto used in iron determinations. This difficulty however may be completely overcome

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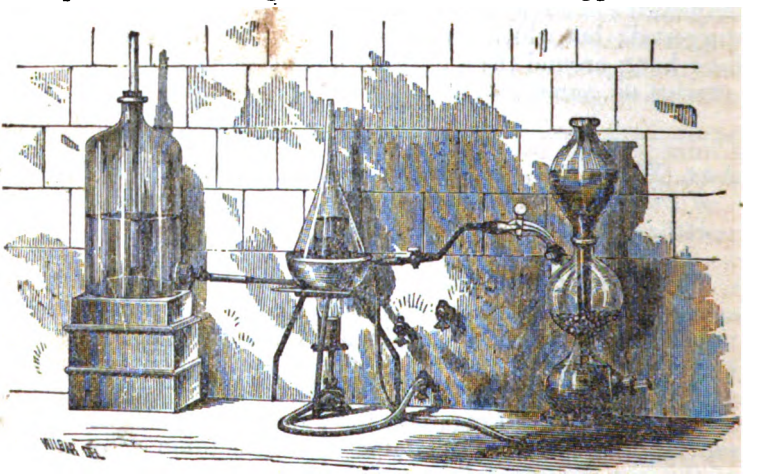
by the apparatus represented in the accompanying figure which, although it may appear complicated at first sight, is really a simple combination of parts, which are familiar in every laboratory.

To the sides of a common copper water bath are attached three tubes as is shown in the figure. The tube on the left connects with a Mariotte's flask by which the water is maintained at a constant level in the bath. The upper tube on the right connects with a carbonic acid gas generator, while the lower tube (connected with the sink by a rubber hose), serves simply as an overflow for the water. On the cover of the water-bath close to the rim is a depressed circular groove, which receives the lip of an inverted glass tunnel. When the apparatus is in



use this groove is kept full of water by the spray from the boiling liquid and thus forms a perfect water joint; but in order to secure this result the bath must be kept nearly full of water and holes for the ready escape of the steam and spray should be provided in the copper rings, which cover the bath and adapt it for vessels of various sizes. It is evident that, by this simple modification of the ordinary water-bath, we can keep our assay surrounded by an atmosphere of steam or of carbonic acid, as may be desirable, during the whole process of digestion, and that too for an indefinite period. Moreover while watching the process through the glass we can either pour in fresh quantities of the solvent, or we can stir up the material, in the vessel within, introducing a tube-tunnel or stirrer through the spout of the covering tunnel.

After the above description the method of making the iron assay will be readily understood. A small amount of the finely

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pulverized mineral (from one-half a gram to a gram) is weighed out in a large platinum crucible. Upon this we pour a mixture of dilute sulphuric acid (sp. gr. 1·5) with as little hydrofluoric acid as experience may show is required to dissolve* the mineral stirring up the material with a platinum spatula. The crucible is next transferred to the water bath, the covering tunnel put in place, water poured into the groove, the interior filled with carbonic acid from the generator and the gas lamp lighted. As soon as the water boils, the connection with the generator is closed, and if the water level has been properly adjusted, the apparatus will take care of itself, the groove will be kept full of water and the interior of the tunnel full of steam. If the materials cake on the bottom of the crucible,—as is not unfrequently the case when a large amount of insoluble sulphate is formed,—the lamp may be removed, the apparatus again filled with carbonic acid, and the contents of the crucible stirred up as above described. A stout platinum wire about two inches long, cemented before the blowpipe to the end of a glass tube, makes an excellent stirring rod, and after using it any adhering material can easily be washed back into the crucible by directing the jet from the wash bottle down the throat of the covering tunnel. The lamp may then be replaced, the current of carbonic acid interrupted and the process of digestion continued. When the decomposition is complete the current of carbonic acid gas is reëstablished, the lamp extinguished and the air tube of the Mariotte's flask raised until its lower end is above the level of the overflow. A slow current of water is thus caused to flow through the bath, which soon cools down the whole apparatus. The crucible may now be removed, its contents washed into a beaker glass and the solution diluted with pure water until the volume is about 500 $\overline{\text{c. m.}}^3$, when the amount of protoxyd of iron present can be determined with a solution of permanganate of potassa in the usual way. The total amount of iron present being subsequently determined, the relative proportion of the two oxyds is of course well known. In order to show the accuracy of the method and also to prove that the presence of hydrofluoric acid does not exert any appreciable influence on the permanganate solution we subjoin the following results.

The strength of the solution of permanganate was tested with the double sulphate of ammonia and iron. In each case 1·4 grams of the salt were accurately weighed out and dissolved in about 500 $\overline{\text{c. m.}}^3$ of water. To the first two portions sulphuric acid was alone added while to the last two there was also added a very large amount of hydrofluoric acid, four or five times as

* If the mineral contains lead, baryta, strontia or even lime in any considerable quantity, complete solution cannot of course be obtained, but this is unimportant so long as the mineral is wholly decomposed.

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much as would be required in any mineral analysis. The results were

No. 1,	1·4 grams	iron salt	required	26·35	c. m.³	permanganate.		
No. 2,	"	"	"	"	"	26·35	"	"
No. 3,	"	"	"	"	"	26·4	"	"
No. 4,	"	"	"	"	"	26·45	"	"

From a specimen of very dark green actinolite treated as above described we obtained in three determinations the following results.

No. 1,	0·6913	grams of	mineral	required	14·1	c. m.³	permanganate.	
No. 2,	0·6640	"	"	"	"	13·6	"	"
No. 3,	0·8910	"	"	"	"	18·2	"	"

The per centage composition deduced from this is

	Per cent of FeO.
No. 1,	19·86.
No. 2,	19·95.
No. 3,	19·89.

In order to test still further the efficiency of our apparatus we have several times dissolved 2 decigrams of iron in dilute sulphuric acid and heated the solution in the bath for more than twelve hours without its undergoing the slightest oxydation.

It is of course essential in this process that both the sulphuric and hydrofluoric acids should be perfectly pure and wholly free from any oxydizing or reducing agents. There is no difficulty in obtaining from the manufacturers pure sulphuric acid, but unfortunately the commercial hydrofluoric acid is apt to be very impure and must be carefully purified by repeated distillation before it is used in this process. The apparatus here described will also be found very useful in the ordinary iron assays and is also applicable in a large number of analytical processes, where it is necessary that the assay should not be exposed to the air. Of course in such cases a glass beaker would take the place of the platinum crucible, as is shown in the figure. Lastly, this method of heating in an atmosphere of steam will be found very convenient in the many cases where it it is desirable to prevent the evaporation of water during the process. The presence of the steam moreover, prevents to a great degree the escape of the volatile acids; so that in the process above described, the glass covering tunnel is not perceptibly corroded unless the hydrofluoric acid used is very strong.

Cambridge, June 22d, 1867.

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ART. XXXVII.—*The Parks of Colorado*

[THE "San Luis Park" of Colorado, in which the Rio Grande del Norte takes its rise, has recently been described by an anonymous writer, reported on good authority to be Hon. Mr. Gilpin, late Governor of Colorado. This description is so graphic and minute, and exhibits so good an acquaintence with a region which has been but little investigated, that we are led to reprint it from the ephemeral pages in which it has appeared.—EDS.]

The San Luis Park.—The San Luis park is readily entered at the extreme north through the Poncho pass, penetrating the Cordillera from the Arkansas river. This park, of elliptical form and immense dimensions, is enveloped between the Cordillera and Sierra Mimbres. It has its extreme northern point between these two Sierras, where they separate by a sharp angle and diverge: the former to the southeast, the latter to the southwest. The latitude of the Poncho pass is 38° 30′, the longitude 106°. It is one hundred and twenty-five miles southwest from Denver, and thirty-seven miles due west from Canyon City.

Emerging from the Poncho pass, the waters begin to gather and form the San Luis river. This flows to the south through a valley of great beauty, which rapidly widens to the right and left. On the east flank the Cordillera ascends abruptly and continuously, without any foot hills, to a sharp, snowy summit; on the west, foot hills and secondary mountains, rising one above the other, entangle the whole space to the Sierra Mimbres.

The Sawatch river has its source on the inner (eastern) flank of the Sierra Mimbres, about sixty miles south of its angle of divergence from the Cordilleras, and by a course nearly east converges toward the lower San Luis river. It enters upon the park by a similar valley. These two valleys expand into one another around this mass of foot hills, fusing into the open park, whose center is here occupied by the San Luis lake, into which the two rivers converge and discharge their waters.

The San Luis lake, extending south from the point of the foot hills, occupies the center of the park for sixty miles, forming a bowl without any outlet to its waters. It is encircled by immense saturated savannas of luxuriant grass. Its water surface expands over this savanna during the season of the melting snows upon the Sierras and shrinks when the season of evaporation returns. From the flanks of the Cordillera on the east, at intervals of six or eight miles asunder, and at very equal distances, fourteen streams, other than the San Luis, descend and converge into the San Luis lake. The belt of sloping plain between the mountains and the lake, traversed by so many parallel streams, bordered by meadows and groves of cottonwood

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trees, has from this feature the name "Los Alamosos." It is sixty miles in length and twenty wide. On the opposite (western) side, from the flank of the Sierra Mimbres, similar streams, known as the Sawatch, the Carnero, and the Gareta, descend from the west into the lake.

The confluent streams thus converging into the San Luis lake are nineteen in number. The area thus occupied by this isolated lake and drained into it by its converging affluents, forming distinctly the northern section of the park, and being one-third of its whole surface, is classified under the general name of "Rincon."

Advancing onward to the south, along the west edge of the plains, ten miles from the Gareta, the Rio del Norte issues from its mountain gorge. Its source is in the perpetual snows of the peaks of San Juan, the local name given to this stupendous culmination of the Sierra Mimbres. The Del Norte flows from its extreme source due east one hundred and fifty miles, and having reached the longitudinal middle of the park turns abruptly south, and bisecting the park for perhaps one hundred and fifty miles, passed beyond its rim in its course to the Gulf of Mexico. All the streams descending from the enveloping Sierras (other than the Alamosos) converge into it their tributary waters. On the west come in successively the Pintada, the Rio del Gata, the Rio de la Gara, the Conejos, the San Antonio, and the Pieda. These streams, six or eight miles asunder, parallel, equidistant, fed by the snows of the Sierra Mimbres, have abundant waters, very fertile areas of land, and are all of the very highest order of beauty.

Advancing again from the Rincon, at the eastern edge of the plain along the base of the Cordillera, the prodigious conical mass of the Sierra Blanca protrudes like a vast hemisphere into the plain and blocks the vision to the direct south. The road describes the arc of a semi-circle around its base for thirty miles, and reaches Fort Garland.

In the immediate vicinity of Fort Garland, the three large streams, the Yuta, Sangre de Christo, and the Trenchera, descend from the Cordillera, converge, unite a few miles west, and blending themselves in the Trenchera, flow west twenty-four miles into the Rio del Norte. The line of the snowy Cordillera, hidden behind the bulk of the Sierra Blanca, here again reveals itself pursuing its regular south-southeast course and direction. Fourteen miles south is reached the town of San Luis, upon the Calebra river; seventeen miles further is the town of Costilla, upon the Costilla river; fifteen miles further the town of Rito Colorado is reached; eighteen miles onward is the Arroyo Hondo; (between these is the San Cristova;) from the Arroyo Hondo to Taos is fourteen miles; twenty miles beyond Taos is

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the mountain chain whose circle toward the west forms the southern mountain barrier which encloses the San Luis park in that direction.

The San Luis park is then an immense elliptical bowl, the bed of a primeval sea which has been drained; its bottom, smooth as a water surface and concave, is 9,400 square miles in area. It is watered by thirty-five mountain streams, which, descending from the encircling crests of snow, converge, nineteen into the San Luis lake, the rest into the Rio del Norte. An extraordinary symmetry of configuration is its prominent feature. The scenery, everywhere sublime, has the everchanging variety of the kaleidoscope. Entirely around the edge of the plain, and closing the junction of the plain with the mountain foot, runs a smooth glacis, exactly resembling the sea beach, which accompanies the conjunction of the land with the ocean. From this beach rise continuously all around the horizon the great mountains, elevating their heads above the line of perpetual snow. On the eastern side the escarpment of the Cordillera rises rapidly, and is abrupt; on the western side the crest of the Sierra Mimbres is more remote, having the interval filled with ridges, lessening in altitude as they descend to the plain of the park. This continuous shelving flank of the Sierras, completing a perfect amphitheater, has a superficial area equal to that of the level plain which it envelops, and gives to the whole enclosure within the encircling band of snow an area of 18,000 square miles. At an elevation of five or six thousand feet above the plain a level line upon the mountain wall marks the cessation of arborsence, above which naked granite and snow alone are seen. To one who ascends to this elevation at any point, the whole interior of this prodigious amphitheatre is scanned by the eye and swept in at a single glance. Aided by a glass, the smallest objects scattered over the immense elliptical area beneath are discernible through the limpid, brilliant, and translucent atmosphere. Two facts impress themselves upon the senses: the perfect symmetry of configuration in nature and the intense variety in the forms and splendor of the landscape. The colors of the sky and atmosphere are intensely vivid and gorgeous; the dissolving tints of light and shade are forever interchanging; they are as infinite as are the altering angles of the solar rays in their diurnal circuit.

The average elevation of the plain above the sea level is 6,400 feet. The highest peaks have an altitude 16,000 feet above the sea. In the serrated rim of the park, as seen from the plain, projected against the canopy, are discernable seventeen peaks, at very equal distance one from another. Each one differs from all the rest in some peculiarity of shape and position. Each one identifies itself by some striking beauty. From the

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snows of each one descends some considerable river, as well within the park as outward down the external mountain bank.

We recognize, therefore, in the San Luis Park an immense elliptical basin enveloping the sources of the Rio Bravo del Norte. It is isolated in the heart of the continent, twelve hundred miles from the sea. It is morticed, as it were, into the midst of the vast mountain bulk, where, rising gradually from the oceans, the highest altitude and amplitude of the continent is attained. This park spreads it plain from 36° to 38° 30′, and is bisected by the 106th meridian. Its greatest length is 210 miles; its greatest width is 100; its aggregate approximate area is 18,000 square miles.

Such being the geographical position, altitude, and peculiar unique configuration, these features suggest the inquiry into parallel peculiarities of meteorology, geology, physical structure, agriculture, mineralogy, and the economy of labor.

The American people have heretofore developed their social system exclusively on the borders of the two oceans, and within the maritime valleys of moderate altitude, having navigation and an atmosphere influenced by the sea. To them, then, the contrast is complete in every feature, in these high and remote altitudes beyond all influence of the ocean, and specially continental.

There is an identity between the "Valley or Park of the City of Mexico" and the San Luis park which ought to be here mentioned. They are similar, twin basins of the great plateau, classifying together and alike in the physical structure of the continent. Mexico is in latitude 20°, longitude 99°, and at 7,500 of altitude. The width of the continent is here 575 miles (from ocean to ocean,) and the divergence of the Cordilleras is 275 miles, which is here the width of the plateau. At the 39° the continent expands to a width of 8,500 miles between the oceans; the Cordilleras have diverged 1,200 miles asunder, and the plateau has widened the same dimensions. In harmony with this great expansion of the continent are all the details of its interior structure. The "Park of the City of Mexico" is but one-tenth in size and grandeur as compared and contrasted with the San Luis park. Of identical anatomy, the former is a pigmy, the latter a giant. The similtude as component parts of the mountain anatomy is in all respects absolute, as is also true of the other parks, which occupy longitudinally the center of the State of Colorado.

Meteorology.—The atmospheric condition of the San Luis park, like its scenery, is one of constant brilliancy, both by day and night, obeying steady laws, yet alternating with a kind of playfully methodical fickleness. There are no prolonged vernal or autumnal seasons. Summer and winter divide the year.

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Both are characterized by mildness of temperature. After the autumnal equinox the snows begin to accumulate upon the mountains. After the vernal equinox they dissolve. The formation of light clouds upon the crest of the Sierras is incessant. The meridian sun retains its vitalizing heat around the year; at midnight prevails a corresponding tonic coolness. The clouds are wafted away by the steady atmospheric currents coming from the west. They rarely interrupt the sunshine, but refracting his rays, imbue the canopy with a shining silver light, at once intense and brilliant. The atmosphere and climate are essentially continental, being uninterruptedly salubrious, brilliant, and tonic.

The flanks of the great mountains, bathed by the embrace of these irrigating clouds, are clad with dense forests of pine, fir, spruce, hemlock, aspen, oak, cedar, pinon, and a variety of smaller fruit trees and shrubs, which protect the sources of springs and running rivulets. Among the forests alternate mountain meadows of luxuriant and nutritious grasses. The ascending clouds, rarely condensed, furnish little irrigation at the depressed elevation of the plains, which are destitute of timber, but clothed in grass. These delicate grasses, growing rapidly during the annual melting of the snows, cure into hay as the aridity of the atmosphere returns. They form perennial pastures, and supply the winter food of the aboriginal cattle, everywhere indigenous and abundant.

An infinite variety in temper and temperature is suggested as flowing from close juxtaposition of extreme altitudes and depressions; permanent snows, running rivers, and the concentric courses of the mountains and rivers. Storms of rain and wind are neither frequent nor lasting. The air is uniformly dry, having a racy freshness and exhilarating taste. A soothing serenity is the prevailing impression upon those who live perpetually exposed to the seasons. Mud is never anywhere or at any time seen. Moderation and concord appear to result from the presence and contact of elements so various.

The critical conclusions to which a rigid study of nature brings the scrutinizing mind are the reverse of first impressions. The multitudinous variety of nature adjusts itself with a delicate harmony which brings into healthy action all the industrial energies. There is no use for the practice of professional pharmacy. Chronic health and longevity characterize animal life. The envelope of cloud-compelling peaks, the seclusion from the oceans, the rarity of the air inhaled, and the absence of humidity disinfect the earth, the water, and the atmosphere of exexhalations and miasmas. Health, sound and uninterrupted, stimulate and sustain a high tone of mental and physical eneryg. All of these are banished, as it were, by the perpetual brilliancy

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and salubrity of the atmosphere and landscape, whose unfailing beauty and tonic taste stimulate and invite the physical and mental energies to perpetual activity.

Geology and Minerals.—As a geological basin, the San Luis park is in the highest degree interesting and remarkable. It is found to contain, intermingled and in order, a complete epitome of all the elements of which geological science and research take note. Its intra-mural locality between the primeval crests of the Cordillera, on the east, and the Sierra Mimbres, (here called the "San Juan,") on the west, multiplies this variety indefinitely. These primary Sierras, separated by the park, face one another in full sight, as they rear their flanks from the opposite edges of the concave plain. The successive periods and stupendous forces which have expended themselves to produce what is in sight, and then subsided to an eternal rest, each particularly manifest itself. The comb of the Sierra presents the prodigious plates of primeval porphyry driven up, as the subsoil of a furrow, from the lowest terrestrial crust and protruding their vertical edges toward the sky.

This summit yielding to the corroding forces, presents a wedge toward the canopy; is arranged in peaks resembling the teeth of a saw; is above all arborescence, and is either clad in perpetual snow, or is bald rock.

Against this is lapped perpendicularly the second stratum, less by many thousand feet in altitude, its top forming a brim or bench. This bench, being the rended edge of the erupted stratum, softer than the first and receiving the debris from above, has a deep, fertile soil, a luxuriant alpine vegetation, forests of fir and aspen, and is the highest region of arboresence and vegetable growth.

This is the region of rocks where the metals, especially gold and silver, abound in crevices charged and infused with the richest ores. It is from hence that the gold of the gulches is disintegrated and descends. Here are springs of water and and the sources of rivers. The timber is excellent and the pastures of various grasses luxuriant and inexaustible. Swept by ascending currents of vapor, irrigation is constant. This elevated bench is a permanent characteristic of the mountain flank, continuous as the continent itself; a collossal staircase whose steps are themselves of mountain magnitude. It is here, at these surfaces of contact of the erupted plates of the lowest terrestrial crust, that the thread of the "gold belt" is revealed and found. From this thread, as from a core outward, the precious metals taper in quantity and become diluted in the immensity of the rocks, as a hill of rock salt disappears to the eye, dissolved in the immensity of the ocean.

The top of this continuous bench is undulating, broad, and

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occasionally crossed by transverse ridges and the chasms of water-courses. The front flank of this bench forms the stupendous escarpment of the mountains, everywhere lofty and precipitous. It is cut through by innumerable streams, up whose gorges access to the upper regions is attained, and the internal contents, the intestines, as it were, of the rocks are revealed to sight and search.

Forming the pediment of this stupendous mural escarpment is the second brim or bench (being the lowest) in the general mountain descent. Here the approaching elevation of the plain, the increase in size of the streams, the accumulating debris from above, and the increased atmospheric abrasion, all unite to obliterate the angularity of the rocks and impair the striking distinctness of formation. Forests of pine and deciduous trees prevail. The flora and vegetation is abundant and various. The atmospheric irrigation becomes uncertain, and the rocks are covered with soil or the fragments of their own superficial destruction. Immediately following is the broad space occupied by the fusion of the mountain base and the plain gently descending to meet it. Here is a profile infinitely indented and broken; alternately the sloping ridges protrude their ribs into the plain, and the plain advances its valleys between them to receive the streams. This is the region of the placers, where is checked in its descent and lodged beneath the alluvian soil the free gold washed down by torrents from the overhanging summits.

This sketch of the normal structure and configuration of the Cordillera is illustrated by a chequered list of details in its minute elements. The primeval rocks, heated to incandescence, rest in their vertical positions unaltered from their original form; they have been roasted but not liquified. Original strata of limestone and gypsum, uplifted on high but not destroyed, rest upon the summit as a torn hat. Gypsum, limestones, slates, clays, shales, are thus found near the highest summits. The decay of the secondary rocks gives extraordinary fertility to the mountain flanks and to the alluvial bottoms below. Hence the luxuriance of the arborescence, the pastures, and the flora. The altitude of the summits gathers and retains the snows, whose glaciers give birth to innumerable rivers. These gash the precipitous flanks with chasms, up which roads ascend; the composition of the rocks is here revealed; the mysteries of their interior contents are unravelled, and the secretions of nature subjected to the human eye and hand.

Thus, then, erects itself the primeval Cordillera, constructed of horizontal plates, vertically thrown up by stupendous volcanic forces, partially altered or roasted by incandescent heat, but neither destroyed nor recast in form; the secondary rocks are

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tossed and scattered high in the upper regions, but are not calcined by flame. The metallic ores are as various as is the variety of the rocks, enriched by heat and exposed by upheaval and corrosion. No lava, no pumice, no obsidien, nothing of melted matter from the plutonic region is seen. This furrowing of the terrestrial crust has alone occupied and exhausted the stupendous volcanic throes of the subterranean world of fire.

Sierra Mimbres.—The Sierra Mimbres, forming the western envelope of the park, is not dissimilar to the Cordillera in its origin, composition, and configuration. Rising from the level of the great plateau, it is of inferior bulk and rank. It forms the backbone from whose contrasted flanks descend the waters of the Rio del Norte on the east, and of the Colorado on the west.

Craters of extinct volcanoes are numerous; streams of lava, once liquid, abound; pedrigals of semi-crystalline basalt submerge and cover the valleys into which they have flowed, and over which they have hardened.

This Sierra, then, has a general direction from north to south, corresponding with the 109th meridian. It has all the characteristics in miniature of the Cordillera, but is chequered and interrupted by the escape of subterranean fires, having areas overflowed and buried beneath the erupted current. Where the nascent springs of the Rio del Norte have their birth, the Sierra Mimbres culminate to stupendous peaks of perennial snow, locally named Sierra San Juan.

The concave plain of the San Luis park, begirt by this elliptical zone of the Sierras, thus capped with a ragged fringe of snow projected upward against the canopy, is the receptacle of their converging waters. It is a bowl of vast amplitude, which has for countless ages received and kept the sedimentary settlings of so prodigious a circuit of Sierras, builded up with every variety of form, structure and geological elements elsewhere found to enter into the architecture of nature. Hither descend the currents of water, of the atmosphere, of lava. The rocks rent from the naked pinnacles, tortured by the intense vicissitudes which assail them; the fragments rolled by the perpetual pressure of gravity upon the descending slopes; the sands and soils from the foundations of rocks and clays of every gradation of hardness; the humus of expired forests and annual vegetation; elements carbonized by transient fires; organic decay; all these elements descend, intermingle, and accumulate.

This concave plain is, then, a bowl filled with sedimentary drift, covered with soil and varnished over as it were with vegetation. The northern department or Rincon, closely embraced by the Sierras and occupied by the San Luis lake, is a vast sa-

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vanna deposited from the filtration of the waters, highly impregnated with the mountain debris. Beneath this soil is a continuous pavement of peat, which maintains the saturation of the super-soil, and is admirable for fuel.

The middle region of the plain, longitudinally, displays a crater of the most perfect form. The interior pit has a diameter of twenty miles, from the center of which is seen the circumferent wall forming an exact circle, and in height five hundred feet. This wall is a barranca, composed of lava, pumice, calcined lime, metamorphosed sandstone, vitrified rocks, and obsidien. This circumferent barranca is perforated through by the entrance and departure of the Rio del Norte, the Calebra, and the Costilla rivers, which traverse the northern, western and southern edges of the interior. By this and other forces of corrosion this barranca is on these three sides cut into isolated hills, called cerritos, of every fantastic form and of extraordinary beauty of shape and tints. The bottom of the crater has been filled up with the soils resulting from the decay of this variety of material, introduced by the currents of the water and of the atmosphere. It is beveled by these forces to a perfect level; is of the fattest fertility, and drained through the porous formation which underlies it.

From this crater to its southern rim, a distance of sixty-five miles, the park expands over a prodigious pedrigal formed from it in the period of volcanic activity. This pedrigal retains its level, and is perforated by the the Rio del Norte, whose longitudinal course is confined in a profound chasm or cañon, of perpendicular walls of lava, increasing to the depth of 1,200 feet, where it debouches from the jaws of this gigantic flood of lava, near the village of La Joya, in New Mexico. Such are the extraordinary forms and stupendous dimensions with which nature here salutes the eye and astonishes the imagination. The expansion of the lava is all to the south, following the descent toward the sea. Toward the north, repelled by the ascent, are waves demonstrating the defeated effort to climb the mountain base.

Such is an imperfect sketch of this wonderful amphitheater of the Sierras. Its physical structure is infinitely complex, exhibiting all the elements of nature piled in contact, yet set together in order and arranged in harmony; its cloud-compelling Sierras, of stern primeval matter and proportions; its concave basin of fat fertility; its atmosphere of dazzling brilliancy, tonic temperature, and gorgeous tints; its arable and pastoral excellence, grand forests, and multitude of streams; its infinite variety of mines and minerals, embracing the whole catalogue of metals, rocks, clays and fuel; its capacity to produce grain, flax,

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wool, hides, vegetables, fruits, meats, poultry, and dairy food; the compact economy of arrangement which blends and interfuses all these varieties; these combine to provoke, stimulate, and reward the taste for physical and mental labor.

Entrance and exit over the rim of the park is everywhere made easy by convenient passes. Roads re-enter upon it from all points of the compass and every portion of the surrounding continent. These are not obstructed at any season. On the north is the Poncho pass, leading to the Upper Arkansas river, and into the south park. On the east, the Mosca and Sangre de Christo passes debouch immediately upon the great plains. On the south is the channel of the Rio del Norte. On the west easy roads diverge to the rivers Chamas, San Juan, and toward Arizona. In the northwest the Cocha-to-pee opens to the great Salt Lake and the Pacific. Convenient thoroughfares and excellent roads converge from all points and diverge with the same facility.

The system of the four parks, extending to the north, indefinitely amplifies and repeats all that characterizes the San Luis park. Smaller in size and less illustrated by variety, each one of the three by itself lingers behind the San Luis, but is an equal ornament in the same family. Their graceful forms, their happy harmony of contact and position, make their aggregated attractions the fascinating charm and glory of the American continent.

The abundance and variety of hot springs of every modulation of temperature is very great. These are also equalled by waters of medicinal virtues. It has been the paradise of the aboriginal stock, elsewhere so abundant and various. Fish, waterfowl, and birds of game and song and brilliant plumage frequent the streams and groves. Animal life is indefinite in quantity and abundantly various.

The atmospheric currents which sweep away every exhalation and all traces of malaria and miasma have an undeviating rotation. These currents are necessarily vertical in direction and equable in force, alternating smoothly as land and sea currents of the tropical islands of the ocean. The silence and serenity of the atmosphere are not ruffled; the changing temperature alone indicates the motion of nature.

All around the elliptical circumference of the plain, following as it were its shore, and bending with the indented base of the mountain, is an uninterrupted road of unparalleled excellence. This circuit is five hundred miles in length, and is graced with a landscape of uninterrupted grandeur, variety and beauty; on the one hand the mountains, on the other hand the concave plain, diversified with groves of alames and volcanic cerritos. At short intervals of five or ten miles asunder are crossed the

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swift-running current and fertile meadows of the converging mountain streams. Hot springs mingle their warm water with all these streams, which swarm with delicate fish and waterfowl.

The works of the beaver and otter are everywhere encountered, and water power for machinery is of singularly universal distribution. Agriculture classifies itself into pastoral and arable; the former subsisting on the perennial grasses, the latter upon irrigation everywhere attained by the streams and artificial acequias. This concave configuration and symmetry of structure is remarkably propitious in economy of labor and production, favored by the juxtaposition and variety of material, by the short and easy transport, and by the benignant atmosphere.

The supreme excellence of position, structure, and productions thus grouped within the system of the parks of Colorado, occupying the heart of the continental home of the American people, is conclusively discernable. Here is the focus of the mountains, of the great rivers and of the metals of the continent. The great rivers have here their extreme sources, which interlock and form innumerable and convenient passes from sea to sea. From these they descend smoothly to both oceans by continuous gradations. The parks occupy the line of the fortieth degree, and offer the facilities for a lodgement in force, at the highest altitude, where the highest divide of the continent exists, half way between the trough of the Mississippi and the Pacific shore. Being immediately approachable over the great plains their mines of precious metals are the nearest in the world to the social masses of the American people and to their great commercial cities. Their accessibility is perfect. All the elements of a perfect economy, food, health, geographical position, innumerable mines of the richest ores and every variety, erect, assist, and fortify one another.

The San Luis park has twenty-four thousand population. These people are of the Mexican-American race. Since the conquest of Cortez, A. D. 1520, the Mexican people have acquired and adopted the language, religion, and in modified forms the political and social systems of their European rulers. A taste for seclusion has always characterized the aboriginal masses, heightened by the geographical configuration of their peculiar territory. Upon the plateau elevated seven thousand feet above the oceans, and encased within an uninterrupted barrier of snow, reside nine millions of homogeneous people. An instinctive terror of the ocean, of the torrid heats and malarious atmosphere of the narrow coasts on either sea, perpetually haunts the natives of the plateau. To them navigation is unknown and marine life is abhorrent. The industrial energies of the people always active and elastic, and always recoiling from the sea, have expanded to the north, following the longitudinal direction

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of the plateau, of the mountains, and of the great rivers. This column of progress advances from south to north; it has reached and permanently occupies the southern half of the San Luis park.

At the same moment the column of the American people advancing in force across the middle belt of the continent, from east to west, is solidly lodged upon the eastern flank of the Cordillera, and is everywhere entering the parks through the passes. These two American populations, all of the Christian faith, here meet front to front, harmonize, intermarry, and reinvigorate the blended mass with the peculiar domestic accomplishments of each other.

The Mexican contributes his primitive skill, inherited for centuries without change, in the manipulations of pastoral and mining industry, and in the tillage of the soil by artificial irrigation. The American adds to these machinery and the intelligence of expansive progress. The grafted stock has the sap of both. As the coming continental railroad hastens to bind together our people isolated on the seas, a longitudinal railroad of 2,000 miles will unite with this in its middle course, bisecting the Territory, States and cities of 10,000,000 of affiliated people. This will fuse and harmonize the isolated peoples of our continent into one people, in all the relations of commerce, affinity and concord.

San Louis di Calebra, July 5, 1866.

ART. XXXVIII.—*Contributions to the Mineralogy of Nova Scotia;* by Prof. O. C. MARSH, of Yale College.—No. 1. *Ledererite identical with Gmelinite.*

DURING their first geological excursion to Nova Scotia, in 1827, Dr. C. T. Jackson, and the late Francis Alger, Esq., discovered a mineral at Cape Blomidon which has since been the subject of no little discussion among mineralogists.* These authors apparently regarded it from the first as a new species, but other authorities differed widely as to its true nature. Mr. Brooke of London, after measuring the angles of a crystal, pronounced it to be apatite, a view subsequently controverted by M. Dufrénoy of Paris, while Dr. Torrey of New York considered it nepheline.

Dr. Jackson subsequently described the mineral under the name *Ledererite*, in honor of Baron von Lederer, then Austrian Consul at New York;† and in the same paper Dr. A. A. Hayes, gave the results of an analysis he had made, on which its claims

* Memoirs Am. Acad., vol. i. p. 253.

† This Journal, vol. xxv, p. 78.

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to be considered a distinct species were mainly founded. The mineral examined had a specific gravity of 2·169, and its composition, according to this analysis, was as follows:—

Silica,	49·47
Alumina,	21·48
Lime,	11·48
Soda,	3·94
Phosphoric acid,	3·48
Oxyd of iron,	0·14
Foreign matter,	·03
Water,	8·58
	98·60

The large amount of phosphoric acid, and the small percentage of water obtained, although the determination of the latter was not entirely satisfactory, left the true character of this mineral still a matter of doubt. Berzelius attempted to clear up the difficulty by proposing a formula, based upon Dr. Hayes's analysis, according to which the mineral would consist of three atoms of lime-analcime and one of apatite.*

This view was adopted by Mr. Alger, who suggested also that the crystalline form of the analcime might have been changed to a hexagonal prism by the phosphate of lime.† Rammelsberg proposed to reject the phosphoric acid as an impurity, and with it an amount of lime sufficient to form tribasic phosphate of lime. This would leave a silicate differing from chabazite in having one-third the amount of water, and hence a lime-analcime.‡ The probable identity of Ledererite with Gmelinite appears to have been first suggested by the editors of the London and Edinburgh Philosophical Magazine in 1834;§ and Prof. Shepard, in his Mineralogy of 1835, and Prof. Dana, in his first edition in 1837, place it under that species. This view was subsequently accepted by both Mr. Alger and Dr. Jackson.‖ Finally Descloizeaux, in his Manuel (1862), published measurements of crystals by himself which sustain it.

Although the identity of Ledererite and Gmelinite was thus rendered highly probable, the chemical proof was still wanting, and it was very desirable to obtain more of the mineral for further investigation. At the request of Mr. Alger, the writer made a careful search for it at Cape Blomidon during several visits to Nova Scotia, but without success until the summer of 1861, when a number of crystals were found near the original locality, which had long been supposed to be exhausted. This was on the north coast of Cape Blomidon, at a point nearly op-

* Jahresbericht, xiv, 175. † Alger's Phillipp's Mineralogy, p. 630.
‡ Handwörterbuch, vol. i, p. 387. § Vol. iv, p. 394.
‖ Boston Soc. Nat. Hist. Journal vol. v, p. 306.

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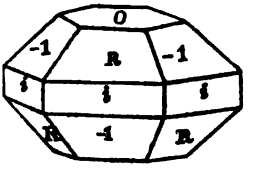
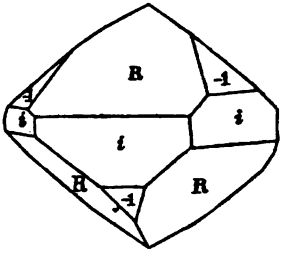
posite Cape Sharp. The crystals were found in geodes in the amygdaloid, accompanied by analcime and quartz, and in most instances implanted upon the latter substance. They were subsequently shown to Mr. Alger, who pronounced them identical with the Ledererite discovered by himself and Dr. Jackson.

The crystals were from one-tenth to one-third of an inch in diameter. Some of them, especially the smallest, were colorless, and nearly transparent; others were yellowish-white or faint salmon-red, and translucent. All were in the form of short hexagonal prisms with pyramidal terminations, as shown in the accompanying figures, that represented in fig. 1 being the typical form. In all the crystals observed the sides of the prisms were marked with horizontal striæ, while the planes of the pyramids were striated parallel to their polar edges. These striæ were in most instances much more distinct than those seen occasionally on crystals of Gmelinite from Irish localities, or from Iceland. There was, moreover, in most of the specimens a tendency toward a rhombohedral form, as seen in the much greater prominence of alternate pyramidal planes, a peculiarity rarely observed hitherto in Gmelinite. In several of the crystals this resulted in the form given in fig. 2.

1.



2.



As the amount of the mineral obtained was sufficient for a chemical examination, the writer, while a student at Heidelberg in 1863, made two analyses of it in the laboratory, and under the direction of Prof. Bunsen.

An attempt was first made to decompose the finely powdered mineral with hydrochloric acid, but without success, although continued over the water-bath for forty-eight hours. A second trial was made in the same way with sulphuric acid, but strange to say, the mineral was apparently little affected. In consequence of this unexpected difficulty, a portion of the mineral which remained was decomposed by hydrofluoric acid, according to Brunner's method, and the constituents, as given below in analysis No. 1*b*, separated in the usual manner. A third portion of the mineral was first used for a determination of

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the water, as given in No. 1*a*, and then fused with carbonate of soda, and its silica separated. A portion of the same mineral, but from a neighboring locality on Cape Blomidon, was also decomposed by fusion with carbonate of soda, and its composition, as given in analysis No. 2, determined in accordance with the usual methods. The amount employed in each analysis was one gram. The specific gravity of the mineral used in No. 1, was 2·108; in No. 2, 2·099, and the hardness in each case was about 4·5. The other physical, and the pyrognostic characters of the mineral, corresponded essentially with those observed in typical Gmelinite. The results obtained in the analyses were as follows:—

	1.		2.
	a	*b*	
Silica,	53·71	....	51·32
Alumina,		17·63	18·45
Lime,		6·52	6·40
Potash,		·80	by loss, 3·48
Soda,		3·10	
Phosphoric acid,		trace	....
Water,	17·98	....	20·35
		99·74	100.00

On comparing these results with those obtained by Dr. Hayes in his analysis, the only one previously made of Ledererite, it will be seen that they differ widely in respect to the amount of phosphoric acid and water—the two important points, in fact, which had occasioned discussion as to the nature of the mineral. It should perhaps, be added that in consequence of this discussion, special precautions were taken to guard against error in determining these substances. The small amount of material at command, rendered it impossible to repeat the analyses; but the results of those completed make clearly evident, what has long been suspected, that the phosphoric acid, found by Mr. Hayes, must be regarded as an impurity, and that Ledererite has essentially the same amount of water as Gmelinite, and hence is identical with that species. The evidence of this identity becomes still more apparent on comparing the composition of the Cape Blomidon mineral, deduced indirectly from a calculation of its constituents as given below, with the results obtained in analyses of typical Gmelinite.

The excess of silica obtained, especially in the first analysis, taken in connection with the remarkable difficulty of decomposition, naturally suggested the presence of impurities in the mineral; and, on examining with the microscope some fragments of a nearly colorless crystal, a quantity of minute crys-

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tals of quartz disseminated through the mass were detected. Several other crystals from the same locality were examined, and all found to contain quartz. This discovery clearly explained the large amount of silica obtained in analyzing the mineral, and also, perhaps, its resistance to decomposition.*

If, now, the results obtained in the above analyses be viewed in the light of this discovery, it is evident that the true composition of the mineral can only be ascertained from them by rejecting the quartz. Assuming, then, that the excess of silica in the substance analyzed was due to quartz,—of which, indeed, the microscopical examination afforded good evidence—and calculating from analysis No. 1, first the oxygen ratios respectively of the protoxyd bases, alumina, silica and water, they are found to be, 2·78 : 8·24 : 28·64 : 15·95, or very nearly 1 : 3 : $10\frac{1}{3}$: 6. As the oxygen of the bases should have to that of the silica the ratio of 1 : 2, all of the latter in excess must belong to the quartz. This would give 12·37 per cent for the amount of quartz in the mineral examined. Deducting this from the quantity of silica obtained, there remains but 41·34 of this substance for combination with the bases, and 87·37 for the sum of the constituents of the mineral itself. By calculating the percentage of these various constituents on the basis of the sum total of the first analysis, it becomes evident that the real composition of Ledererite, thus determined, is as follows :—

Silica,	47·19
Alumina,	20·13
Lime,	7·44
Potash,	·91
Soda,	3·54
Water,	20·53
	99·74

These results give the oxygen ratio of 1 : 3 : 8 : 6, and indicate for the mineral the formula $(\frac{1}{3}\dot{N}a+\frac{2}{3}\dot{C}a)\dddot{S}i+\dddot{A}l\dddot{S}i^{3}+6\dot{H}$, thus clearly establishing its identity with Gmelinite. In chemical consitution it differs from the normal Gmelinite only in having a considerable part of the soda replaced by lime, resembling in this respect the variety from Antrim, Ireland, analyzed by Connell.†

The fact that crystals of this Gmelinite from Cape Blomidon contained 12·37 per cent of silica as an impurity is a very important one, not merely in its bearing on the paragenesis of minerals, but especially for the explanation it suggests of many

* Prof. Bunsen informed the writer that he once experienced a similar difficulty in analyzing a specimen of Chabazite, but made no special examination for impurities.

† Edin. Phil. Jour., xxiv, 362.

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difficulties hitherto experienced in reconciling the results of analyses, particularly of silicates. On this point M. Lechartier of Paris has recently published some interesting facts, relating especially to the impurities detected in staurotide.*

New Haven, Oct. 10th, 1867.

ART. XXXIX.—*Notes on Fossils recently obtained from the Laurentian Rocks of Canada, and on objections to the organic nature of Eozoon;* by J. W. DAWSON, LL.D., F.R.S., F.G.S., *with Notes* by W. B. CARPENTER, M.D., F.R.S.

I. *Specimen of Eozoon from Tudor, C. W.*—This very interesting specimen, submitted to me for examination by Sir W. E. Logan, is, in my opinion, of great importance, as furnishing a conclusive answer to all those objections to the organic nature of *Eozoon* which have been founded on comparisons of its structures with the forms of fibrous, dendritic, or concretionary minerals,—objections which, however plausible in the case of highly crystalline rocks, in which organic remains may be simulated by merely mineral appearances readily confounded with them, are wholly inapplicable to the present specimen.

a. *General Appearance.*—The fossil is of a clavate form, six and a half inches in length, and about four inches broad. It is contained in a slab of dark-colored, coarse, laminated limestone, holding sand, scales of mica, and minute grains and fibers of carbonaceous matter. The surface of the slab shows a weathered section of the fossil; and the thickness remaining in the matrix is scarcely two lines, at least in the part exposed. The septa, or plates of the fossil, are in the state of white carbonate of lime, which shows their form and arrangement very distinctly, in contrast to the dark stone filling the chambers. The specimen lies flat in the plane of stratification, and has probably suffered some compression. Its septa are convex toward the broad end, and somewhat undulating. In some places they are continuous halfway across the specimen; in other places they divide and reunite at short distances. A few transverse plates, or connecting columns, are visible; and there are also a number of small veins or cracks passing nearly at right angles to the septa, and filled with carbonate of lime, similar in general appearance to the septa themselves.

On one side, the outline of the fossil is well preserved. The narrow end, which I regard as the basal portion, is rounded. The outline of the side first bends inward, and then outward, forming a graceful double curve, which extends along the greater

* Bulletin de la Soc. Chimique, May, 1865, p. 375.

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part of the length. Above this is an abrupt projection, and then a sudden narrowing; and in the middle of the narrow portion, a part has the chambers obliterated by a white patch of carbonate of lime, below which some of the sèpta are bent downward in the middle. This is probably an effect of mechanical injury, or of the interference of a calc-spar vein.

With the exception of the upper part above referred to, the septa are seen to curve downward rapidly toward the margin, and to coalesce into a lateral wall, which forms the defined edge or limit of the fossil, and in which there are some indications of lateral orifices opening into the chambers. It is worthy of remark that, in this respect, the present specimen corresponds exactly with that which was originally figured by Sir W. Logan in the 'Geology of Canada,' p. 49, and which is the only other specimen that exhibited the lateral limit of the form.

On the side next the matrix, the septa terminate in blunt edges, and do not coalesce; as if the organism had been attached by that surface, or had been broken before being imbedded.

b. *Microscopic Characters.*—Under the microscope, with a low power, the margins of the septa appear uneven, as if eroded or tending to an acervuline mode of growth; but occasionally the septa show a distinct and regular margin. For the most part merely traces of structure are presented, consisting of small parts of canals, filled with the dark coloring-matter of the limestone. In a few places, however, these appear as distinct bundles, similar to those in the Grenville specimens, but of fine texture.

In a few rare instances only, can I detect, with a higher power, in the margin of some of the septa, traces of the fine tubulation characteristic of the proper chamber-wall of *Eozoon*. For the most part this seems to have been obliterated by the infiltration of the tubuli with colorless carbonate of lime, similar to that of the skeleton.

In comparing the structure of this specimen with that of those found elsewhere, it would appear that the chambers are more continuous, and wider in proportion to the thickness of the septa, and that the canal-system is more delicate and indistinct than usual. In the two former respects the specimens from the Calumet and from Burgess approach that now under consideration more nearly than do those from Grenville and Petite Nation; but it would be easy, even in the latter, to find occasional instances of a proportion of parts similar to that in the present example. General form is of little value as a character in such organisms; and, so far as can be ascertained, this may have been the same in the present specimen and in that originally obtained from the Calumet, while in the specimens from Grenville a massive and aggregative mode of growth seems to have obliterated all distinctness of individual shape. Without additional specimens,

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and in the case of creatures so variable as the Foraminifera, it would be rash to decide whether the differences above noticed are of specific value, or depend on age, variability, or state of preservation. For this reason I refer the specimen for the present to *Eozoon Canadense*, merely distinguishing it as the Tudor variety.

From the state of preservation of the fossil, there are no crystalline structures present which can mislead any ordinarily skilful microscopist, except the minute veins of calcareous spar traversing the septa, and the cleavage-planes which have been developed in some portions of the latter.

I would remark that, as it seemed desirable not to injure any more than was absolutely necessary a unique and very valuable specimen, my observations of the microscopic structure have been made on a few slices of small size,—and that, as the microscopic structures are nearly the same in kind with those of specimens figured in former papers, I have not thought it necessary to prepare numerous drawings of them; while the admirable photograph executed for Sir W. E. Logan by Mr. Norman illustrates sufficiently the general form and arrangement of parts.

c. *Concluding Remarks.*—In a letter to Dr. Carpenter, quoted by him in the 'Quarterly Journal of the Geological Society' for August, 1866, p. 228, I referred to the occurrence of *Eozoon* preserved simply in carbonate of lime. The specimens which enabled me to make that statement were obtained at Madoc, near Tudor, this region being one in which the Laurentian rocks of Canada appear to be less highly metamorphosed than is usual. The specimens from Madoc, however, were mere fragments, imbedded in the limestone, and incapable of showing the general form. I may explain, in reference to this, that long practice in the examination of these limestones has enabled me to detect the smallest *Eozoon* when present, and that in this way I had ascertained the existence of this fossil in one of the limestones of Madoc before the discovery of the fine specimen now under consideration.

I am disposed to regard the present specimen as a young individual, broken from its attachment and imbedded in a sandy calcareous mud. Its discovery affords the hope that the comparatively unaltered sediments in which it has been preserved, and which also contain the worm-burrows described by me in the 'Quarterly Journal of the Geological Society' for November,* will hereafter still more largely illustrate the Laurentian fauna.

II. *Specimens from Long Lake and Wentworth.*—Specimens from Long Lake, in the collection of the Geological Survey of Canada, exhibit white crystalline limestone with light-green compact or septariiform† serpentine, and much resemble some of

* Vol. xxii, p. 608.

† I use the term "septariiform" to denote the *curved* appearance so often presented by the Laurentian serpentine.

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the serpentine limestones of Grenville. Under the microscope the calcareous matter presents a delicate areolated appearance, without lamination; but it is not an example of acervuline *Eozoon*, but rather of fragments of such a structure, confusedly aggregated together, and having the interstices and cell-cavities filled with serpentine. I have not found in any of these fragments a canal-system similar to that of *Eozoon Canadense*, though there are casts of large stolons, and, under a high power, the calcareous matter shows in many places the peculiar granular or cellular appearance which is one of the characters of the supplemental skeleton of that species. In a few places a tubulated cell wall is preserved, with structure similar to that of *Eozoon Canadense*.

Specimens of Laurentian limestone from Wentworth, in the collection of the Geological Survey, exhibit many rounded siliceous bodies, some of which are apparently grains of sand, or small pebbles; but others, especially when freed from the calcareous matter by a dilute acid, appear as rounded bodies, with rough surfaces, either separate or aggregated in lines or groups, and having minute vermicular processes projecting from their surfaces. At first sight these suggest the idea of spicules; but I think it on the whole more likely that they are casts of cavities and tubes belonging to some calcareous Foraminiferal organism which has disappeared. Similar bodies, found in the limestone of Bavaria, have been described by Gümbel, who interprets them in the same way.* They may also be compared with the siliceous bodies mentioned in a former paper as occurring in the Loganite filling the chambers of specimens of *Eozoon* from Burgess.

III. *Specimens from Madoc.*—I have already referred to fragments of *Eozoon* occurring in the limestone at Madoc, one of which, found several years ago, I did not then venture to describe as a fossil. It projected from the surface of the limestone, being composed of a yellowish dolomite, and looking like a fragment of a thick shell. When sliced, it presents interiorly a crystalline dolomite, limited and separated from the enclosing rock by a thin wall having a granular or porous structure and excavated into rounded recesses in the manner of *Eozoon*. It lies obliquely to the bedding, and evidently represents a hollow flattened calcareous wall filled by infiltration. The limestone which afforded this form was near the beds holding the apparently worm-burrows described in the Society's Journal for November, 1866.

[A thin section of this body, carefully examined microscopically, presents numerous and very characteristic examples of the canal-system of *Eozoon*, exhibiting both the large widely branch-

* Proceedings of Royal Academy of Munich, 1866; Q. J. G. S., vol. xxii, pt. i, p. 185 et seq.

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ing systems of canals and the smaller and more penicillate tufts shown in the most perfect of the serpentinous specimens—but with this difference, that the canals, being filled with a material either identical with or very similar to that of the substance in which they are excavated, are so transparent as only to be brought into view by careful management of the light.—W. B. C.]

IV. *Objections to the Organic Nature of Eozoon.*—The discovery of the specimen from Tudor, above described, may appear to render unnecessary any reference to the elaborate attempt made by Profs. King and Rowney to explain the structures of *Eozoon* by a comparison with the forms of fibrous and dendritic minerals,* more especially as Dr. Carpenter has already shown their inaccuracy in many important points. I think, however, that it may serve a useful purpose shortly to point out the more essential respects in which this comparison fails with regard to the Canadian specimens—with the view of relieving the discussion from matters irrelevant to it, and of fixing more exactly the limits of crystalline and organic forms in the serpentine limestones and similar rocks.

The fundamental error of Messrs. King and Rowney arises from defective observation—in failing to distinguish, in the Canadian limestones themselves, between organic and crystalline forms. This is naturally followed by the identification of all these forms, whether mineral or organic, with a variety of purely crystalline arrangements occurring in other rocks, leading to their attaching the term "Eozoonal" to any rock which shows any of the characters, whether mineral or organic, thus arbitrarily attached to the Canadian *Eozoon*. This is obviously a process by which the structure of any fossil might be proved to be a mere *lusus naturæ*.

A notable illustration of this is afforded by their regarding the veins of fibrous serpentine, or chrysotile, which occur in the Canadian specimens, as identical with the tubulated cell-wall of *Eozoon*—although they admit that these veins traverse all the structures indifferently and do not conform to the walls of the chambers. But any microscopist who possesses specimens of *Eozoon* containing these chrysotile veins may readily satisfy himself that, under a high power, they resolve themselves into *prismatic crystals in immediate contact with each other;* whereas, under a similar power, the true cell-wall is seen to consist of *slender, undulating, rounded threads of serpentine, penetrating a matrix of carbonate of lime.* Under polarized light more especially, the difference is conspicuously apparent. It is true that, in many specimens and parts of specimens, the cell-wall of *Eozoon* is badly preserved and fails to show its structure; but in no instance does it present the appearance of chrysotile, or of any

* Quart. Journ. Geol. Soc., vol. xxii, pt. ii, p. 23.

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other fibrous mineral, when examined with care under sufficiently high powers. In my original examination of Sir William Logan's specimens from Grenville and the Calumet, I did not detect the finely tubulated cell-wall, which is very imperfectly preserved in those specimens; but the veins of fibrous serpentine were well known to me; and when Dr. Carpenter discovered the tubulation of the cell-wall in the specimens from Petite Nation, I compared this structure with that of these veins, and satisfied myself of its distinctness before acceding to his conclusions on this point.

It would also appear that the radiating and sheaf-like bundles of crystals of tremolite, or similar prismatic minerals, which occur in the Canadian serpentines, and also abound in those of Connemara, have been found with the tubulation of *Eozoon*; but these crystals have no definite relation to the forms of that fossil, and often occur where these are entirely absent; and in any case they are distinguishable by their straight prismatic shape and their angular divergence from each other. Much use has also been made of the amorphous masses of opaque serpentinous matter which appear in some parts of the structure of *Eozoon*. These I regard as, in most cases, simply results of alteration or defective preservation, though they might also arise from the presence of foreign matters in the chambers, or from an incrustation of mineral matter before the final filling up of the cells. Generally their forms are purely inorganic; but in some cases they retain indications of the structures of *Eozoon*.

With reference to the canal-system of *Eozoon*, no value can be attached to loose comparisons of a structure so definite with the forms of dendritic silver and the filaments of moss-agates; still less can any resemblance be established between the canal-system and vermicular crystals of mica. These occur abundantly in some serpentines from the Calumet, and might readily be mistaken for organic forms; but their rhombic or hexagonal outline when seen in cross section, their transverse cleavage-planes, and their want of any definite arrangement or relation to any general organic form are sufficient to undeceive any practised observer. I have not seen specimens of the metaxite from Reichenstein referred to by Messrs. King and Rowney; but it is evident, from the description and figure given of it, that, whether organic or otherwise, it is not similar to the canals of *Eozoon Canadense*. But all these and similar comparisons are evidently worthless when it is considered that they have to account for definite, ramifying, cylindrical forms, penetrating a skeleton or matrix of limestone, which has itself a definite arrangement and structure, and, further, when we find that these forms are represented by substances so diverse as serpentine, pyroxene, limestone, and carbonaceous matter. This is intelli-

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gible on the supposition of tubes filled with foreign matters, but not on that of dendritic crystallization.

If all specimens of *Eozoon* were of the acervuline character, the comparisons of the chamber-casts with concretionary granules might have some plausibility. But it is to be observed that the laminated arrangement is the typical one; and the study of the larger specimens, cut under the direction of Sir W. E. Logan, shows that these laminated forms must have grown on certain strata-planes before the deposition of the overlying beds, and that the beds are, in part, composed of the broken fragments of similar laminated structures. Further, much of the apparently acervuline *Eozoon* rock is composed of such broken fragments, the interstices between which should not be confounded with the chambers; while the fact that the serpentine fills such interstices as well as the chambers shows that its arrangement is not concretionary.* Again, these chambers are filled in different specimens with serpentine, pyroxene, loganite, calcareous spar, chondrodite, or even with arenaceous limestone. It is also to be observed that the examination of a number of limestones, other than Canadian, by Messrs. King and Rowney, has obliged them to admit that the laminated forms in combination with the canal-system are "essentially Canadian," and that the only instances of structures clearly resembling the Canadian specimens are afforded by limestones Laurentian in age and in some of which (as, for instance, in those of Bavaria and Scandinavia) Carpenter and Gümbel have actually found the structure of *Eozoon*. The other serpentine-limestones examined (for example, that of Skye) are admitted to fail in essential points of structure; and the only serpentine believed to be of eruptive origin examined by them is confessedly destitute of all semblance of *Eozoon*. Similar results have been attained by the more careful researches of Prof. Gümbel, whose paper is well deserving of study by all who have any doubts on this subject.

In the above remarks I have not referred to the disputed case of the common limestones; but I may state that I have not been able to satisfy myself of the occurence of the structures of *Eozoon* in such specimens as I have had the opportunity to examine.† It is perhaps necessary to add that there exists in Canada abundance of Laurentian limestone which shows no indication of the structures of *Eozoon*. In some cases it is evident that such structures have not been present. In other cases they may have been obliterated by processes of crystallization. As in the case of other fossils, it is only in certain beds,

* I do not include here the "septariiform" structure referred to above, which is common in the Canadian serpentine and has no connection with the forms of the chambers.

† Such Irish specimens of serpentine limestone as I have seen, appear much more highly crystalline than the beds in Canada which contain *Eozoon*.

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and in certain parts of those beds, that well-characterized specimens can be found. I may also repeat here that in the original examination of *Eozoon*, in the spring of 1864, I was furnished by Sir W. E. Logan with specimens of all these limestones, and also with serpentine-limestones of Silurian age, and that, while all possible care was taken to compare these with the specimens of *Eozoon*, it was not thought necessary to publish notices of the crystalline and concretionary forms observed, many of which were very curious and might afford materials for other papers of the nature of that criticised in the above remarks.

[The examination of a large number of sections of a specimen of *Eozoon* recently placed in my hands by Sir William Logan, in which the canal system is extraordinarily well preserved, enables me to supply a most unexpected confirmation of Dr. Dawson's statements in regard to the occurrence of dendritic and other forms of this system, which cannot be accounted for by the intrusion of any foreign mineral; for many parts of the calcareous lamellæ in these sections, which, when viewed by ordinary transmitted light, appear quite homogeneous and structureless, are found, when the light is reduced by Collin's "graduating diaphragm," to exhibit a most beautiful development of various forms of canal-system (often resembling those of Dr. Dawson's Madoc specimen, which cross the cleavage-planes of the shell-substance in every direction. Now these parts, when subjected to decalcification, show no trace of canal-system; so that it is obvious, both from their optical and from their chemical reactions, that the substance filling the canals must have been *carbonate of lime*, which has thus completely solidified the shell layer, having been deposited in the canals previously excavated in its interior, just as crystalline carbonate of lime fills up the reticular spaces of the skeleton of Echinodermata fossilized in a calcareous matrix. This fact affords conclusive evidence of *organic structure*, since no conceivable process of crystallization could give origin to dendritic extensions of carbonate of lime disposed on exactly the same crystalline system with the calcite which includes it, the two substances being mineralogically homogeneous, and only structurally distinguishable by the effect of their junction-surfaces on the course of faint rays of light transmitted through them.—W. B. C.]

[The preceding paper was drawn out in part by the observation of Messes. King and Rowney on the Eozoon published in the Quarterly Journal of the Geological Society, vol. xxii, pages 185 to 217, and illustrated by two plates. The following are the *Summary* and *Conclusion* with which the paper of Messrs. King and Rowney closes.—Eds.]

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X. *Summary.*—Although zealous advocates at one time for the organic origin of "eozoonal" Ophite, we now, after a prolonged investigation, and after, as we believe, leaving no point unnoticed, feel ourselves under the necessity of totally relinquishing that opinion.

It has been seen (1) that the "chamber-casts" or granules of serpentine are more or less simulated by chondrodite, coccolite, pargasite, &c., also by the bytryoidal configurations common in Permian Magnesian Limestone; (2) that the "intermediate skeleton" is closely represented, both in chemical composition and other conditions, by the matrix of the above and other minerals; (3) that the "proper wall" is structurally identical with the asbestiform layer which frequently invests the grains of chondrodite—that, instead of belonging to the skeleton, as must be the case on the eozoonal view, it is altogether independent of that part, and forms on the contrary, an integral portion of the serpentine constituting the "chamber-casts," under the allomorphic form of chrysotile—and that perfectly genuine specimens of it, completely simulating *casts* of separated nummuline tubules, occur in true fissures of the serpentine granules; (4) that the "canal-system" is analogous to the imbedded crystallizations of native silver and other similarly conditioned minerals, also to the coralloids imbedded in Permian Magnesian Limestone—that its typical Grenville form occurs as metaxite, a chemically identical mineral imbedded in saccharoidal calcite; (5) that the type examples of "casts of stolen-passages" are isolated crystals apparently of pyroscleric. Furthermore, considering that there has been a complete failure to explain the characters of the so-called internal casts of the "pseudopodial tubules" and other "passages" on the hypothesis of ordinary mechanical or chemical infiltration, also bearing in mind the significant fact that the "intermediate skeleton," in Irish and other varieties of "eozoonal rocks," contains modified examples of the "definite shapes" more or less resembling the crystalline aggregations and prismatic lumps in primary saccharoidal marbles—that "eozoonal" structure is only found in metamorphic rocks belonging to widely separated geological systems, never in their unaltered sedimentary deposits,—taking all these points into consideration, also the arguments and other evidences contained in the present memoir, we feel the conclusion to be fully established, that every one of the specialities which have been diagnosed for "*Eozoon Canadense*" is solely and purely of crystalline origin: in short, we hold, without the least reservation, that, from every available standing point—foraminiferal, mineralogical, chemical, and geological—the opposite view has been shown to be utterly untenable.

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XI. *Conclusion.*—From what has been stated in some of the preceding pages, respecting the various chemical changes which "eozoonal" Ophite appears to have undergone, and its mineralogical constituents, we are strongly inclined to believe that it is a pseudomorphic rock, that it existed at one time in the ordinary metamorphic state, perhaps as hornblendic or augitic gneiss, and that it is primarily of sedimentary origin. Whether the same may be concluded of all ophitic rocks is a question on which we cannot offer any opinion—negative, or affirmative. There are some grounds for believing, however, that certain dolerites, generally considered to be of eruptive origin, have become changed into Ophite: and though we have not detected any "eozoonal" structure in an example apparently of the kind, from Monzoni in the Tyrol, which has fallen under our observation, it would not surprise us if this structure were found in ophitic rocks supposed to belong to the eruptive section, considering that the essential mineral (augite) of dolerite contains a large percentage of silicate of lime.

Art. XL.—*Reply to Mr. Gabb on the Cretaceous rocks of California;* by T. A. Conrad.

In the last number of this Journal, Mr. Gabb in some remarks on the age of certain fossils of California, charges me with an "unfair avoidance of a difficulty." I am not aware of either a difficulty or unfairness. The latter refers to the omission of several of his species in my Eocene Check List. This I did for the sufficient reason that I could not be sure whether his typical form was from division A or B of his Cretaceous rocks. I believe that he has in only one instance figured a supposed identical species from each division, and in that instance the shells are not specifically, nor I think even generically related. After such experience, it could hardly be expected that I should trust his judgment in other comparisons.

Mr. Gabb includes the genus *Anchura* Conrad, in division B, but from his statement in his Paleontology it appears not to have been found associated with other fossils, and therefore it is much more likely to be a genus of division A, inasmuch as it has never been found in the Tertiary of any region. He says that the genera *Gyrodes*, *Perrisolax* and *Margaritella* are strictly Cretaceous, which I admit, but his species of *Perrisolax* in division B, is a member of an Eocene genus *Levifusus*, and which is closely related to a Claiborne species. He makes no mention of *Gyrodes* in division B, in his Paleontology, and of *Margaritella* he refers *M. globosa* to division A, and makes no

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mention of its occurrence in division B, and *M. crenulata* he refers to no particular division.

It can hardly be reasonable to complain of my omission of *Callianassa* in a Check List devoted exclusively to Testacea, and I doubt the identification of such imperfect specimens of crab's hands as he has figured.

I omitted Ammonites n. s. because it was neither figured nor described, and might be an accidental intruder among Eocene fossils, as so many Cretaceous shells have been found to be. Would it be fair to place the Miocene beds of Cape Fear river, N. C., in the Cretaceous formation on account of the presence of two Cretaceous fossils, *Exogyra costata* and *Cucullæa vulgaris ?*

Mr. Gabb compares his division B to the Maestricht beds, but the latter contain Belemnites, Ammonites, Baculites and Hamites, and according to Lyell, no Tertiary species; whereas Mr. Gabb includes in his division B, the Tertiary genera *Aturia, Venericardia, Dosinia, Pseudoliva* and *Ficus.* His *Dosinia elevata,* however, is a species of a very different Eocene genus, *Dosiniopsis* Conrad. *D. pertenuis* Gabb is either another species of *Dosiniopsis* or a younger specimen of *elevata. D. gyrata* is not stated to occur in division A, and *D. inflata* can hardly be a *Dosinia.* Any evidence so far is wanting to prove the strata in question Cretaceous, and as the group of fossils is so decidedly Tertiary in their forms and some species identical, I am forced to the conclusion of their Eocene origin.

Art. XLI.—*Geographical Notices.*

I. Note on the Diversities in published estimates of the Height of Mount Washington, New Hampshire.

The variation, in statements pretending to approach accuracy, concerning the height of Mt. Washington, has been before remarked, but it may be interesting to see, in numerical order, the principal computations, and estimates given, in English feet, above the level of the sea. They are as follows:—

1. 6,103, as quoted by Prof. Jacob Bigelow in an article presently to be mentioned, from the observations of Capt. Alden Partridge, of Norwich, Vt.

2. 6,128, given on the maps of Colton's General Atlas, edition of 1866; though in the text of the same work the height given is 6,496 feet, we are not told on what authority.

3. 6,225, from barometric observations, made in July, 1816, by a botanical party, comprising Prof. Jacob Bigelow, M. D., of

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Harvard College, Dr. Francis Boott, late of London, and Lemuel Shaw, late Chief Justice of Supreme Court of Mass., then all young men. The observations were reduced by Prof. Farrar, of Harvard College. An account by Dr. Bigelow of this visit, is in the New England Journal of Medicine and Surgery, Oct. 1816.

4. 6,226, (or by a series of observations, 6,228,) the height determined by Dr. Chas. T. Jackson, State Geologist, and Messrs. J. D. Whitney, M. B. Williams and Eben Baker, assistants, by barometric and thermometric observations, for a period of 12 hours. See "First Report on Geol. of New Hampshire," 1841, p. 102.

5. 6,238, from barometric observations of Capt. Partridge, in 1821, still retained by some of the Common School Atlases.

6. 6,285, obtained by Prof. Bond, of Cambridge Observatory, with barometer and theodolite. The same result obtained by N. A. Goodwin, C. E., by spirit level. This measurement was adopted by Appleton's New Amer. Cyclopædia, N. Y., 1863.

7. 6,280, from the levelling of Capt. T. J. Cram, Top. Eng., Assist. U. S. Coast Survey, published in Coast Survey Report for 1854. Simultaneous observations, by the barometer, gave 6,206, and by thermo-barometer, boiling point, 6,116.

8. 6,288, Prof. Guyot's final measurement, by barometer, of which a full account is given in this Journal, II, xxxi, 156, March, 1861.

9. 6,290, was a former result obtained by the same, Aug., 1851.

10. 6,293, U. S. Coast Survey, in 1853, (so stated by Prof. Guyot.)

11. 6,428, the result of seven days' observations with a spirit level, Aug. 1820, conducted by Messrs. A. N. Brockett and J. W. Weeks, of Lancaster, N. H., and described in Farmer & Moore's "N. H. Hist. Collections," Apl., 1823, (ii, 97). This measurement is followed in Lippincott's Gazetteer of U. S., Johnston's Physical Atlas, Edinburgh, 1856, the Imperial Gazetteer, Glasgow, 1855, &c.

12. 6,652 is Humboldt's statement (Views of Nature), purporting to follow Lyell. Lyell's "Second Visit to U. S." (1845) gives, however, Dr. Bigelow's measurement.

13. 6,817 (2,078 meters), according to Guibert's Dict. Géographique et Statistique, Paris, 1855.

14. 7,000 and over, McCulloch's Geogr. Dict., edition of 1849.

15. 7,055, and 7,162. In July, 1804, Rev. Manasseh Cutler, LL. D., of Ipswich, Mass., with Dr. W. D. Peck, afterward Prof. of Nat. Hist. at Cambridge, made several barometric observations, which, reduced by Dr. Bowditch (in Mem. Amer. Acad. Arts and Sci., for 1815, vol. iii, pt. 2, p. 326), gave these results.

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16. 7,800. Rev. Samuel Williams, LL.D., previously Prof. of Mathematics in Harvard College, in his Hist. of Vermont, published 1794, calculated from the existence of snow on these mountains from Oct. to July, that they nearly reach the line of perpetual congelation, or 7,872 feet. He calls their altitude hardly more than 7,800.

17. 8,000. "The White Mountains are estimated to be at least 8,000 feet high," according to Elements of Useful Knowledge, by Noah Webster, 1812.

18. 9,800, obtained by the first scientific exploring party on record, in July, 1784, from imperfect barometric observations. Of the party were Dr. Cutler, of Ipswich, Rev. D. Little, of Kennebunk, Col. John Whipple, and Rev. Dr. Belknap. The last furnished an account of the trip to the Amer. Philosophical Society, published 1786, in their Transactions (ii, 42).

19. 10,000 and over. Dr. Belknap, however, in his Hist. of New Hampshire, vol. 3, published 1792, expresses himself "persuaded, that whenever the mountain can be measured with the requisite precision, it will be found to *exceed* 10,000 feet, of perpendicular altitude, above the level of the ocean." He adds, that "this peak has lately been distinguished by the name of Mt. Washington." Mr. E. A. Kendall, an Englishman who traveled through Northern U. S. in 1808, records the same as the usual estimate.

20. 11,000 and over, was the height sanctioned by Morse's series of Geographies, at least as late as 1819.

21. 12,729, according to Pres. Dwight's Travels, 1803 (ii, 163.) "It is proverbially asserted," he says, "along the eastern coast, that Mt. Washington is distinctly visible 30 leagues from the shore." He then estimates the distance as at least 140 miles, and adds: "The elevation of this summit, calculating upon its visibility at this distance, and making the proper allowance for the refraction of light, will be 12,729 feet. Another deduction ought, however, to be made for the fact, that, instead of being seen at the surface, it probably is always first perceived at mast head."

22. Above the lower limit of perpetual snow!—so given in a primary geography published in 1859, at New Haven. "The White Mountains have this name because their tops are covered with snow and ice *all the summer*, as well as in the winter."

II. Notes on Recent Geographical Maps, Books and Intelligence.

Russian America.—The recent purchase of this important province by our government, has awakened special attention to its physical characteristics. We have already announced the departure from San Francisco of a scientific party, who are to

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engage in the exploration of that comparatively unknown region.

By far the best summary, in English, of what is now known respecting Russian America, may be found in the speech of Hon. Charles Sumner, Chairman of the Committee on Foreign Affairs, delivered in the U. S. Senate, when the treaty of cession was presented to that body (Wash. 1867, 8vo, pp. 48). Appended to the pamphlet is a map, which exhibits not merely the newly acquired Alaska, but also its relations to the East coast of Asia, and the great Behrings sea. This map, which is on the scale of 1: 5,000,000, was prepared at the office of the U. S. Coast Survey, and is separately published.

Senator Sumner, with the varied learning for which he is distinguished, recapitulates the sources of information in European literature respecting Alaska, and then proceeds to make up from them all a monograph of the country, considered under these seven heads; first, government; second, population; third, climate; fourth, vegetation; fifth, minerals; sixth, furs; seventh, fisheries. Our limits only allow us, in this brief way, to call attention to this survey. In respect to the climate, we transcribe a striking tabular statement, compiled at the request of Mr. Sumner, from the archives of the Smithsonian Institution, by one of the collaborators who visited Russian America under the auspices of the telegraph company.

	Mean Temperature in degrees Fahrenheit.					Precipitation in Rain or Snow. Depth in inches.				
	Spring.	Summer.	Autumn.	Winter.	Year.	Spring.	Summer.	Autumn.	Winter.	Year.
St. Michales, Russian Amer. Lat. 63° 28′ 45″ North.	28.75	52.25	27.00	7.00	27.48					
Fort Youkon, Russian Am. Lat. (near) 67°.	14.22	59.67	17.37	28.80	16.92					
Ikogmut, Russian America. Lat. 61° 47′.	19.62	49.32	36.05	0.95	24.57					
Sitka, Russian America. Lat. 57° 03′.	39.65	53.37	43.80	32.30	42.12	18.32	15.75	32.10	23.77	89.94
Puget sound, Wash. Ter. Lat. 47° 07′.	48.88	63.44	51.30	39.88	50.75	7.52	3.68	15.13	20.65	46.98
Astoria, Oregon. Lat. 40° 11′.	51.16	61.36	53.55	42.43	52.13	16.43	4.85	21.77	44.15	87.20
San Francisco, California. Lat. 37° 48′.	55.39	58.98	58.29	50.25	55.73	6.65	0.09	2.69	13.49	22.92
Nain, Labrador. Lat. 57° 10′.	28.67	48.57	33.65	0.40	26.40					
Montreal, Canada East. Lat. 45° 30′.	41.20	68.53	44.98	16.40	42.77	7.66	11.20	7.42	.72	27.00
Portland, Maine. Lat. 43° 39′	40.12	68.75	45.75	21.52	42.78					
Fort Hamilton, New York. Lat 40° 37′.	47.84	71.35	55.79	32.32	51.82	11.69	11.64	9.88	10.31	43.29
Washington, Dist. of Col.	54.19	73.07	53.91	33.57	53.69	10.48	10.53	10.16	10.06	41.94

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It will be seen, from this table, that the winters of Sitka are relatively warm, not differing much from those of Washington, and several degrees warmer than those of New York; but the summers are colder. The mean temperature of winter is 32° 30′, while that of summer is 53° 37′. The Washington winter is 38° 57′; the Washington summer is 73° 07′. These points exhibit the peculiarities of this Alaskan coast—warm winters and cool summers.

Inter-oceanic Canals and Railroads, between the Atlantic and Pacific Oceans.—Rear Admiral C. H. Davis, as Superintendent of the National Observatory, prepared last year for the Secretary of the Navy, in pursuance of a resolution of the U. S. Senate, a Report on the means of inter-oceanic communication across the great American Isthmus (Wash. 1867, 8vo., 38 pp. 14 maps). The Report contains a series of important maps and profiles, and among them (in the second edition, March 14, 1867) may be found a very curious copy of a Spanish map of Darien, based on surveys made between 1780 and 1790. All the twenty-six transit projects, including railroads and canals, which have been offered to the world, are briefly characterized by Admiral Davis, important statistical tables are appended, and a bibliographical list of the authorities on the subject is also given. The maps and profiles embody the most important results acquired in the various surveys of Barnard, Squier, Hughes, Trautwine, McDougal, Michler, and others.

Two maps of what is known as the "*North Western Boundary*" between the United States and Great Britain, have just been printed by the Government at Washington. They are compiled under the direction of Archibald Campbell, Commissioner, and John G. Parke, U. S. Eng., Chief Astronomer and Surveyor of the N. W. Boundary Survey.

The country delineated, is that lying between the 110th meridian, the sea coast, and between the parallels of 46° and 49° 30′, N. lat. Thus the basins of the Columbia and Fraser rivers, and Vancouver's Island, etc., are included. The effort has been made to present not merely the original work of the survey, but also the investigations of other British and American explorers. The topography is quite in detail, but is not always satisfactory, especially in the representation of mountains. For example, the marked predominance of Mt. St. Helens, and Mt. Adams, above the adjacent country, would not be inferred from the map. The publication of the accompanying Report of the Commission, is deferred as we learn by a letter of the Commissioner, until the meeting of Congress.

Copies of the *Journal of the Royal Geographical Society of London*, vol. xxxvi, for 1866, have just been received. It contains

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more than the usual variety of interesting papers and maps. Among them, we may mention an account, by M. Chandless, of his ascent of the River Purûs, one of the chief tributaries of the Amazon, in 1864 and 1865. He has drawn a map of the river, from his own astronomical observations and measurements. The astronomical data are said to be the first ever ascertained, notwithstanding that there have been four previous surveys of the river. Mr. Chandless also contributes a paper on the river Aquiry, the principal affluent of the river Purûs. For these unaided surveys over a distance of 1,866 miles, the Geographical Society awarded to Mr. Chandless the Victoria gold medal. Two articles, translated from the Russian of M. Veniukof, convey a large amount of interesting matter, respecting the knotty and hitherto unsatisfactory geography of the Bolor Dagh, and the country of the Belors.

Five numbers have reached us of a new "*Dictionnaire de Géographie Ancienne et Moderne*" (Paris, Didot, 1866-7, 8°), designed as a sort of supplement to Brunet's well known "*Manuel du Libraire.*" Though prepared for bibliographers, the work will be of great value to any student of geography or history,—as it gives, in the first part, the modern equivalents of the ancient names of European places, and in the second part, the ancient designations, corresponding to modern French names. The only corresponding work, in common use, is that of Bischoff & Möller, but this new publication promises to be even more convenient and complete. With its help, it will be easy for the ordinary reader to identify, at once, the names of places, referred to by writers in the middle ages, and now recognized with difficulty in the nomenclature of modern maps and lexicons.

Behm's "*Geographisches Jahrbuch,*" (Leipsic, 12°) for 1866, is a valuable manual for ready reference in geographical studies. It is designed to convey, in the first place, geographical statistics respecting all the countries of the globe, arranged not alphabetically, but continent-ally,—including the areas and population of provinces and states, according to the latest local authorities. This part is followed by tables of the principal known heights of mountain-peaks and of lakes, measurements of river basins, and select climatic data. Several short articles on the recent progress of geographical science, by different writers, come next; and the volume is concluded, by a collection of tables, designed to facilitate the transfer of geographical measurements, from the terminology of one country to that of another. A work so useful deserves general encouragement.

From recent numbers of Petermann's Journal we gather the following intelligence.

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The northernmost land of the Globe.—The publication of Dr. I. I. Hayes's final report on his researches in 1860 and 1861, has given Dr. Petermann occasion to present a series of five maps illustrative of the progress of discovery in the basin north of Baffin's Bay. The first of these shows the base outline of Baffin's Bay as given by Bylot and Baffin in 1616, a rude sketch with scarcely ony details. The second shows the careful coast survey of Ross, two hundred years later, in 1818. Smith's sound is represented as land-locked except on the south. In the third map, Inglefield's passage in 1852 through Smith's sound nearly to 80° N., is exhibited. Then comes a sketch of Dr. Kane's researches extending to Mt. Parry in about lat. 82°, and finally Dr. Hayes's penetration to Cape Union, the most northern point yet attained is about 82° 30′. A full memoir accompanies his maps.

Marine currents of the North Circumpolar basin.—The conclusion of an elaborate paper by A. Mühry, presents the following results of his investigations.

"As an outward current, one stream flows from the east and another from the west along the edge of the Polar basin, where in winter a rim of continental ice is formed, and in summer these currents float this ice away. Thus there exists a floating ice ice-girdle, some twenty or thirty geographical miles in breadth, in which the walfishery is pursued. Scoresby did not reach the northern rim, but Parry did and passed over it. The inward current, the gulf stream, has a breadth from the southwest coast of Greenland to the northwest coast of Norway. Both polar streams dip under,—the eastern on the southeast coast of Greenland, the western on the east side Newfoundland, sinking beneath the gulf stream as a counter polar current where the temperatures are related as 0° to 7° and to 12° Reaum. The counter or anti-polar currents of the gulf stream dip under in four places, on the west side of Nova Zembla, Spitzbergen, Iceland and South Greenland, where the temperatures are related as 3° to 0° Reaum. The fact also indicates that along the middle line of the basin a current flows toward the aperture."

Malden's Island.—This island, (referred to as a deposit of guano by Prof. J. D. Hague, in this Journal II, xxxiv, p. 242,) has been taken possession of by a mercantile house of Melbourne in the name of the British Government. It belongs to a group of small coral islands, (lat. 4° 15′ S., long. 155° W.), which the U. States had previously claimed, and which was subsequently known as the "American Polynesia."

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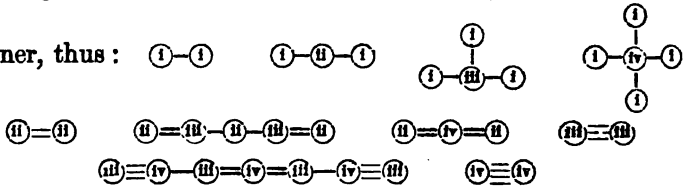
Art. XLII.—*On normal and derived Acids;* by George F. Barker.*

The law of saturation by equivalence, introduced into chemistry by Kekulé, determines at once the formula of every possible binary compound.† Assuming that the simple radicals may be divided into four groups, it will be seen that the number of binary compounds is limited to the following ten classes; monads with monads, as $K'Cl'$; with dyads, as $O''H'_2$; with triads, as $Au'''Cl'_3$; and with tetrads, as $Pt^{iv}I'_4$; dyads with dyads, as $Mg''O''$; with triads, as $As'''_2O''_3$; and with tetrads, as $C^{iv}O''_2$; triads, with triads, as $B'''N'''$; and with tetrads, as $Zr^{iv}_3N'''_4$; and finally tetrads with tetrads, as $Pt^{iv}Si^{iv}$. The number of atoms therefore, which enter into such compounds, is determined by a very simple mathematical law. On this fact rests the possibility of graphic representation. Of the various methods in use, that of A. Crum Brown, in which the atom is represented by a circle, and its equivalence by projecting lines called bonds or units of attraction, is perhaps the best. As every compound body must be saturated, i. e., have all its bonds engaged, the ten classes given above may be very clearly represented in this manner, thus:



Here it will be noticed, no bonds are exchanged by similar atoms; i. e., those of the same element.

* In this paper, H=1, O=16, S=32, C=24, Al=55, Si=56, etc.

† When two radicals unite together, the number of atoms of each required for mutual saturation, is obtained by dividing the least common multiple of the numbers representing their equivalencies by the equivalence of each. Generally, the number of atoms of each radical is inversely as its equivalence, four triad atoms saturating three tetrads, for example. Atoms thus combined, alternate with each other, the two units of attraction in each exchange, belonging to dissimilar radicals.

When, however, similar atoms unite directly, two units of attraction disappear for each pair of atoms, being occupied in holding these atoms together. Two tetrad atoms thus combined, have therefore an equivalence of six, three such atoms of eight, four of ten, etc. Or, as Kekulé has shown (Lehrbuch, 1861, i, 163), the number of units of attraction left free by the union of any number of carbon atoms is equal to twice the number of such atoms, plus two ($=2n+2$). C. G. Foster has extended this law to all the poly-equivalent radicals (Watts' Dictionary, i, 1007) giving the formula $E=S-2(n-1)$, in which E indicates the group-equivalence, n the number of poly-equivalent atoms, and S the sum of their units of attraction. By this formula, the highest number of hydrogen atoms which can be united with ten carbon atoms for example, is $40-2(10-1)=22$, giving the hydrocarbon $C_{10}H_{22}$. From this a series of lower compounds may be formed, each differing from the next higher, by H_2.

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If now any of these bonds be left unsatisfied, or in other words, if the chemical edifice represented by the molecule be incomplete, it is evident that the whole structure, whatever its complexity, is capable of entering into combination by its free bond or bonds. Hence in this case, the compound body will act precisely like a simple radical having the same equivalence. Such unsaturated bodies are called compound radicals and their equivalence or combining power is exactly equal to the number of unsatisfied bonds. These compound radicals, therefore, may be used in place of the simple radicals, in the formulas above given; thus forming a new set of compounds, which, since the number of compound radicals possible is almost unlimited, are exceedingly numerous. The compound radicals most in use are those derived from the hydrogen compounds of the different groups of simple radicals, by successive unsaturation. If from the ordinary so-called types, HCl, H_2O, H_3N, H_4C an atom of hydrogen be removed, there is left Cl', $(HO)'$, $(H_2N)'$, $(H_3C)'$, all monad compound radicals. By continuing the process where it is possible, radicals of higher equivalence are thus produced.

With these facts premised, I pass to the subject of the present paper; i. e., the consideration of the bodies which result from the union of the monad compound radical hydryl $(HO)'$ with the simple radicals. Representing H_2O by Ⓗ–Ⓞ–Ⓗ, hydryl is Ⓗ–Ⓞ–, which may be represented either by a larger circle or by the letters alone, thus HO–. From the principles above stated, we deduce the formulas Ⓘ–OH HO–Ⓘⓘ–OH HO–Ⓘⓘⓘ(H)(H)–OH and HO–Ⓘⓥ(H)(H)–OH. What is the character of the bodies thus obtained?

A reply to this question becomes possible only by classifying the simple radicals according to their electro-chemical characters. In the method of classification given above, the elements are divided according to the *quantity* of their combining power i. e., to their equivalence; here the division is into positive and negative, according to the *quality* of this combining power. When a *positive* simple radical combines with hydryl, a *base* is produced; when a *negative* simple radical so unites, an *acid* results. If, for example, the vertical columns in the table below, represent the equivalence, increasing from left to right, and the horizontal the electro-chemical character, we may illustrate these statements as follows:—

	Monad.	*Dyad.*	*Triad.*	*Tetrad.*
−	$Cl'(HO)$	$S''(HO)_2$	$B'''(HO)_3$	$C^{iv}(HO)_4$
+	$K'(HO)$	$Ca''(HO)_2$	$Bi'''(HO)_3$	$Zr^{iv}(HO)_4$

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The formulas in the upper row represent well known acids, and those in the lower, as well known bases.

It has been thus far assumed that the equivalence of a radical is invariable. But it seems evident that when one element combines with another in more than one proportion, its combining power must be different in the two cases. Thus in stannic oxyd SnO_2 and stannous oxyd SnO; tin is evidently a tetrad in the former case and a dyad in the latter. In all cases, however, the equivalence changes by two, either up or down; it therefore never alters from even to odd or the reverse. A dyad may act as a tetrad or hexad; a monad as a triad, pentad or heptad. Applying this principle now to the compounds of the radicals with hydryl, we notice that the negative radicals vary their equivalence by several stages, forming a series of acids; but that the positive radicals rarely form more than a single series of bases, their equivalence being fixed at a single stage. With negative radicals, we may have for example:—

Monad.	*Dyad.*	*Triad.*	*Tetrad.*
$Cl'(HO)$	$S''(HO)_2$	$P'''(HO)_3$	$Sn^{iv}(HO)_4$
$Cl'''(HO)_3$	$S^{iv}(HO)_4$	$P^{v}(HO)_5$	- - - - -
$Cl^{v}(HO)_5$	$S^{vi}(HO)_6$	- - - -	- - - - -
$Cl^{vii}(HO)_7$	- - - -	- - - -	- - - - -

But the only instance of such changes with the positive radicals, is in the case of the perhydrates of the alkaline earths; as $Ba^{iv}(HO)_4$, $Sr^{iv}(HO)_4$, etc., the composition of which, however, is not fully decided.

I. It will be noticed in the formulas of the acids above given that the number of atoms of oxygen and of hydrogen are equal, and also that they are equal to the equivalence of the radical. Such acids, thus simply derived, I propose to call normal acids. A normal acid then, is one which contains as many atoms of oxygen and of hydrogen as is equal to the equivalence of the radical. They may be designated by prefixing *ortho* to the name of the acid, as proposed by Odling. Fixing now the acid termination *ic* for each group of the negative elements, the other terminations are readily obtained by the ordinary rule. Thus in the chlorine group, the radical in the *ic* acid has an equivalence of five; in the sulphur group, of six; in the nitrogen group, of five; and in the carbon group, of four. The acids in the above tables have consequently the following names:—

$Cl'(HO)$ Ortho-hypochlorous acid, $S''(HO)_2$ Ortho-hyposulphurous acid.
$Cl'''(HO)_3$ Ortho-chlorous acid, $S^{iv}(HO)_4$ Ortho-sulphurous acid.
$Cl^{v}(HO)_5$ Ortho-chloric acid, $S^{vi}(HO)_6$ Ortho-sulphuric acid.
$Cl^{vii}(HO)_7$ Ortho-perchloric acid,

$P'''(HO)_3$ Ortho-phosphorous acid, $Sn^{iv}(HO)_4$ Ortho-stannic acid.
$P^{v}(HO)_5$ Ortho-phosphoric acid.

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In all the ortho acids the number of atoms of replaceable hydrogen, and therefore the basicity, is equal to the equivalence of the radical. Quite a number of these acids are known, either in the free state or in their salts. Of these, ortho-hypochlorous $HClO$, and hypo-bromous $HBrO$, ortho-iodous H_3IO_3, ortho-hyposulphurous H_2SO_2, ortho-nitrous H_3NO_3, ortho-boric H_3BO_3, ortho-carbonic H_4CO_4, silicic H_4SiO_4, stannic H_4SnO_4, and titanic H_4TiO_4, and ortho-antimonic acids H_5SbO_5 may be mentioned.

II. But it is at once evident that this simplicity of constitution of the acids is far from universal; indeed the large majority of acids have a composition essentially different. In general, the acids of the chlorine group are monobasic, those of the sulphur group dibasic, those of the nitrogen group mono- or tribasic, and those of the carbon group dibasic. The basicity of an acid containing a single atom of a perissad radical, however, is never even, nor that containing an artiad radical odd.

Now an acid, like any other ternary, may be formed by the union of two binaries; but in the case of acids, one of these binaries is water. Thus Cl_2O hypochlorous oxyd uniting with hydric oxyd H_2O gives $H_2Cl_2O_2$ or $(HClO)_2$, two molecules of ortho-hypochlorous acid. So SO_3 sulphuric oxyd, and H_2O form H_2SO_4, the ordinary sulphuric acid. Conversely, abstraction of the elements of water from an acid yields again the negative oxyd or anhydrid. A false view of this fact it was, which gave rise to the old dualistic formulas, in which water is represented as existing as such in the acids. In all monobasic acids, however, two molecules of the acid are required to furnish one molecule of water; in dibasic acids, one molecule is required, in tribasic acids $\frac{2}{3}$ of a molecule, and in tetrabasic acids $\frac{1}{2}$ a molecule. The number of molecules of water which can be added to a negative oxyd to form an acid is determined by the equivalence of the simple radical which it contains. Thus in SO, sulphur is a dyad, and only a single molecule of water can be added to it, $SO+H_2O=H_2SO_2$, thus producing the normal acid. In SO_2, sulphur is a tetrad and two such additions are possible before reaching ortho-sulphurous acid, $SO_2+H_2O=H_2SO_3$, and $SO_2+(H_2O)_2=H_4SO_4$. In SO_3, sulphur is a hexad and three molecules of water may unite successively, $SO_3+H_2O=H_2SO_4$, $SO_3+(H_2O)_2=H_4SO_5$, and $SO_3+(H_2O)_3=H_6SO_6$, yielding finally the normal acid as before. The reverse process also is readily performed. Indeed, Graham long ago showed that a single molecule of tribasic phosphoric acid by the loss of H_2O, afforded a monobasic phosphoric acid. In the passage then, from the normal acids to the negative oxyds (or anhydrids), there may be as

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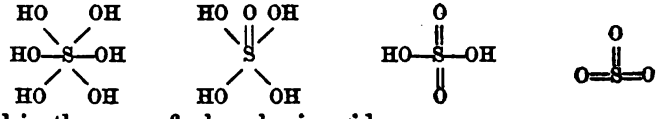
many intermediate acids as successive abstractions of H_2O from the normal acids, will permit. Thus, chlorine may yield

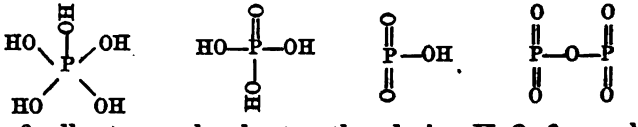
	Monad.	*Triad.*	*Pentad.*	*Heptad.*
Ortho,	$HClO$	H_3ClO_3	H_5ClO_5	H_7ClO_7.
Mono-meta,	....	$HClO_2$	H_3ClO_4	H_5ClO_6.
Di-meta,	....	....	$HClO_3$	H_3ClO_5.
Tri-meta,	....	....	....	$HClO_4$.

To the monobasic phosphoric acid which Graham obtained from the ordinary tribasic acid, by the removal of H_2O, he gave the name meta-phosphoric acid. And although the etymological signification of this prefix has entirely disappeared, yet it is so generally used in the science, that it may be well to retain it; and to define a meta-acid as one formed from an ortho-acid by the loss of one or more molecules of water. Moreover, since there may be several such acids, derived from a single ortho-acid, I propose to prefix the Greek numerals to the meta, in order to distinguish them; as in the above table, where ordinary chloric acid, being two removes from ortho-chloric acid, is named di-meta-chloric acid. Conversely by adding to the meta-acid the number of molecules of water indicated by the Greek numeral prefix, its corresponding ortho-acid is obtained.

From the foregoing considerations, the general conclusion may be drawn, that all acids are either ortho or meta-acids; the ortho-acids being formed by saturating all the free bonds of any negative radical by the monad hydryl; and the meta-acids being derived from these by the loss of the elements of water. It is plain then, that the equivalence of the radical is the same both in the normal acids and in those derived from them; and that they differ in the fact that in the former all the bonds are united to hydryl, while in the latter some of them are saturated by oxygen. This is very clearly represented by the graphic method. In the passage from ortho-sulphuric acid H_6SO_6 to the negative oxyd SO_3, we have



and in the case of phosphoric acid—



where finally, two molecules together losing H_2O, form phosphoric oxyd P_2O_5. It will be noticed that the tribasic acid, called by Odling ortho-phosphoric acid, is really mono-meta-phosphoric acid; while the common meta form is a di-meta-acid.

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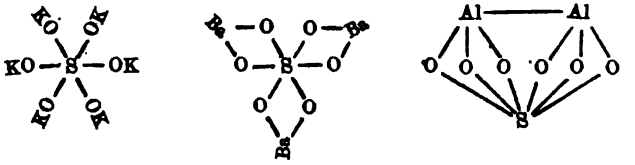
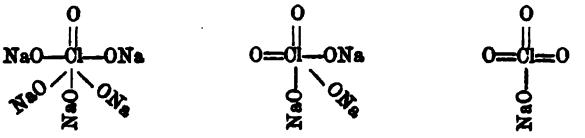
The above facts, we may remark in passing, throw much light on the manner of writing rational formulas. In all ternary compounds properly so called, the positive and the negative radicals are united by oxygen; indeed, this is the definition of an acid, a base and a salt. In all normal acids and their salts all the oxygen performs a linking function, thus:—

Potassic ortho-sulphate. Baric ortho-sulphate. Aluminic ortho-sulphate.



But in the derived or meta-acids a part of the oxygen is united with the radical by both its bonds, and hence takes no part in binding the radicals together.* In all the mono-meta acids one atom of oxygen is thus united, in the di-meta acids two, etc. For example,

Sodic mono-meta-perchlorate. Sodic di-meta-perchlorate. Sodic tri-meta-perchlorate.



This difference may be expressed by the ordinary formulas, thus: ortho salts $Cl—OK$, $S=(OK)_2$, $B\equiv(OK)_3$ etc.; meta, $(PO)\equiv O_2Bi'''$, $(NO_2)—OK$, $(ClO_3)—OAg$, etc; or better in the form of the early typical formulas $\left.\begin{matrix}Cl'\\K\end{matrix}\right\}O$, $\left.\begin{matrix}S''\\Na_2\end{matrix}\right\}O_2$, $\left.\begin{matrix}B'''\\K_3\end{matrix}\right\}O_3$, and $\left.\begin{matrix}(PO)'''\\Bi'''\end{matrix}\right\}O_3$, $\left.\begin{matrix}(NO_2)'\\K\end{matrix}\right\}O$, $\left.\begin{matrix}(ClO_3)'\\Ag\end{matrix}\right\}O$. Hence it appears desirable that the form of the water type should be retained for rational formulas, since by it, this essential difference in the function of the oxygen may be readily indicated. $\left.\begin{matrix}(PO_2)'\\Cs\end{matrix}\right\}O$ designates at once cæsic di-meta-phosphate, $\left.\begin{matrix}(NO)'''\\Bi'''\end{matrix}\right\}O_3$ bismuthic mono-meta nitrate, $\left.\begin{matrix}(SO_2)''\\Mg''\end{matrix}\right\}O_2$ magnesic di-meta-sulphate, $\left.\begin{matrix}(SO)^{iv}\\Pt^{iv}\end{matrix}\right\}O_4$ platinic mono-meta-sulphate, $\left.\begin{matrix}(SO)''\\Na_2\end{matrix}\right\}O_2$

* This direct union is proved by the fact that this oxygen may be replaced by a radical of no uniting power, like the monad chlorine, for example, without breaking up the molecule; while the oxygen which unites the radicals to each other, cannot be so replaced without decomposing the molecule.

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sodic mono-meta-sulphite, $\left.\begin{matrix}(ClO_3)'\\ Rb\end{matrix}\right\}O$, rubidic tri-meta-perchlorate, etc.

With the knowledge of the constitution of the acids above given, it may be interesting to examine the various groups of acid-forming or negative radicals, to see how far they conform to the law. Commencing with the monads, the chlorine group is the only one which forms acids. All the possible ortho and meta acids of chlorine are given in the table, page 388. Of these, those in italics, all of which are monobasic, are known with certainty, though polybasic acids of chlorine have been supposed, on experimental grounds, to exist.* In the case of iodine, however, mono-meta-iodic acid H_3IO_4, or $\left.\begin{matrix}(IO)'''\\ H_3\end{matrix}\right\}O_3$, and di-meta-iodic acid HIO_3 or $\left.\begin{matrix}(IO_2)'\\ H\end{matrix}\right\}O$ are known; so also are mono-meta-periodic acid H_5IO_6, di-meta-periodic acid H_3IO_5, and tri-meta-periodic acid HIO_4. Ortho-hypoiodous acid HIO, is supposed to exist. The acids of bromine have been but little studied; ortho-hypobromous acid $HBrO$, and di-meta-bromic acid $HBrO_3$ are the only ones satisfactorily established.

The dyad negative radicals include the sulphur and the iron groups. The substances composing the latter group, however, form bases when they act as dyads, are ambiguous as tetrads, and only form acids when they are hexads. Selenium and tellurium form no compounds which are not yielded by sulphur. The latter may stand, therefore, as the representative of both groups. It may form

	Dyad.	*Tetrad.*	*Hexad.*
Ortho-hyposulphurous	H_2SO_2.	sulphurous H_4SO_4.	sulphuric H_6SO_6
Mono-meta	.....	H_2SO_3	H_4SO_5
Di-meta	.....	.....	H_2SO_4

The three dibasic acids above given are the ordinary ones. But the two hydrates of sulphuric acid, so called, correspond to H_6SO_6 and H_4SO_5; and from these are obtained similar salts, as Hg''_3SO_6, and Zn''_2SO_5. The acids formed by the iron group are similar to those of hexad sulphur, the di-meta form being the more common; as in H_2CrO_4, H_2MnO_4, and H_2FeO_4. Chromium, however, forms acids, whose salts are well known, corresponding to the three sulphuric acids above given. With mercury and bismuth, there are the ortho-chromates Hg''_3CrO_6 and Bi'''_2CrO_6; and with lead, the mono-meta-chromate Pb''_2CrO_5. Manganese in its tetrad stage, appears capable of forming a mono-meta acid, corresponding to

* Crystallized hydric perchlorate, according to Roscoe, is H_2ClO_5 the di-meta form.

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H_2SO^3. No true permanganic acid is known; since the acid so-called does not contain the metal as an octad. If its formula be written $HMnO_4$, monobasic, as the isomorphism of its salts with the perchlorates would seem to require, then manganese must be a heptad like chlorine; nor do we escape from this conclusion by writing it $H_2Mn_2O_8$, as will be seen farther on.

The acids of triad radicals may be divided into two groups; those of boron and gold, which have no higher equivalence: and those of nitrogen, phosphorus, arsenic, antimony, and bismuth, which have a quinquivalent stage. Of the former, boron forms an ortho-acid H_3BO_3 and a mono-meta-acid HBO_2; gold only a mono-meta-auric acid, $HAuO_2$. The acids of the nitrogen group may be represented as follows:

	Triad.		*Pentad.*
Ortho-nitrous	H_3NO_3	nitric	H_5NO_5
Mono-meta	$H\,NO_2$		H_3NO_4
Di-meta	.....		$H\,NO_3$

Salts have been obtained corresponding to all these acids of nitrogen; as plumbic ortho-nitrite $Pb''_3(NO_3)_2$, and potassic mono-meta nitrite KNO_2; dihydro-bismuthic ortho-nitrate $H_2Bi'''NO_5$, magnesic mono-meta-nitrate $Mg''_2(NO_4)_2$ and sodic di-meta-nitrate $NaNO_3$. No acid of triad phosphorus is known, if we except the calcic ortho-phosphite $Ca''_3(PO_3)_2$, corresponding to it. As quinquivalent however, all the above acids of phosphorus are known; the mineral libethenite is hydro-di-cupric ortho-phosphate HCu''_2PO_5; and triple phosphate dried at 100° C., has the formula $H_2(NH_4)MgPO_5$, di-hydro-ammonio-magnesic ortho-phosphate. Similar salts of iron and manganese have been obtained. The mono-meta-phosphoric acid H_3PO_4 is the ordinary tribasic form (Odling's ortho-acid), and the di-meta acid is the common monobasic or meta acid of Graham. It may here be remarked that the acids, called hypophosphorous and phosphorous, are misnamed, since the radical phosphorus is not trivalent in the latter and univalent in the former as analogy with the other acids, and indeed as the principles of nomenclature would require; but as Frankland has represented, both these acids contain phosphorus as a pentad. If the principles above stated be correct, it is evident that the number of atoms of basic hydrogen can never exceed those of the oxygen by which it is linked to the acid radical. In H_3PO_2 the hydrogen is in excess, and it is at once apparent that the acid cannot be tribasic; that one atom of the hydrogen at least, must be united directly with the phosphorus. Experiment shows us that in fact two atoms of hydrogen are thus directly united, the acid being monobasic. Its rational formula, therefore, is

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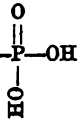
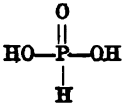
$\left.\begin{matrix}(H_2PO)'\\ H\end{matrix}\right\}O$, and it may be viewed as di-meta-phosphoric acid $\left.\begin{matrix}(PO_2)'\\ H\end{matrix}\right\}O$, in the radical of which H_2 has replaced O. In phosphorous acid H_3PO_3, a single atom of hydrogen being united directly to the phosphorus, the other two are replaceable by basic metals, yielding acid and neutral salts, having the formulas $\left.\begin{matrix}(HPO)''\\ HR\end{matrix}\right\}O_2$ and $\left.\begin{matrix}(HPO)''\\ R_2\end{matrix}\right\}O_2$ as Rammelsberg has shown. All three hydrogen atoms may be replaced by the alcoholic radicals, forming neutral ethers; but only two atoms of this radical—those which have replaced the basic hydrogen—can be exchanged for a metal, to form salts. The third atom, replacing as it does, the alcoholic hydrogen, is still retained, forming alcoholic phosphorous acids. The constitution of these acids may be graphically represented thus:

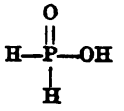
Phosphoric acid.



Phosphorous acid.



Hypophosphorous acid.



Since they are formed from mono-meta-phosphoric acid by replacing hydryl by hydrogen, they resemble the phosphoric chlorhydrines, to be considered farther on.

Acid compounds of arsenic exist, corresponding to all the forms given above. Plumbic ortho-arsenite $Pb''_3(AsO_3)_2$, hydro-cupric ortho-arsenite $HCu''AsO_3$, and di-hydro-potassic ortho-arsenite H_2KAsO_3; plumbic and potassic mono-meta-arsenites, $Pb''(AsO_2)_2$ and $KAsO_2$; hydro-di-cupric ortho-arsenate HCu''_2AsO_5 (olivenite), sodic mono-meta-arsenate Na_3AsO_4, and potassic di-meta-arsenate $KAsO_3$, are examples. Antimony forms argentic ortho-sulphantimonite Ag_3SbS_3 (pyrargyrite), argentic mono-meta-sulphantimonite $AgSbS_2$ (miargyrite) and mono-meta-antimonous acid $HSbO_2$; ortho-antimonic acid H_3SbO_5, mono-meta antimonic acid H_3SbO_4, (and the salts $Pb''_3(SbO_4)_2$ and K_3SbS_4) di-meta-antimonic acid $HSbO_3$ and potassic di-meta-antimonate $KSbO_3$. The compounds of bismuth are little known. Kobellite is a plumbic ortho-sulph-bismuthite $Pb''_3(BiS_3)_2$; and di-meta-bismuthic acid $HBiO_3$ has also been obtained.

The negative radicals of the tetrad group include carbon, silicon, tin and titanium. Carbon may form

Ortho-carbonous acid	H_2CO_2	carbonic	H_4CO_4
Mono-meta	.....		H_2CO_3

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Of the first, there is evidence to believe it is represented by formic acid.* Both ortho-and meta-carbonic acids form numerous salts. Calcic ortho-carbonate Ca''_2CO_4, cupric ortho-carbonate $Cu''_2CO_4 + aq$ (malachite) and hydro-tri-cupric ortho-carbonate $H_2Cu''_3(CO_4)_2$, (azurite) are examples of the former; and the common carbonates K_2CO_3, $BaCO_3$, etc., of the latter. The division of the silicates into ortho-and meta-salts, has been very clearly represented by Prof. Dana in the last number of this Journal. Ortho- and meta-stannates and titanates are well known compounds.

Of radicals having a higher equivalence, the pentads tantalum and columbium, forming a series of acids similar to quinquivalent phosphorus, and the hexads molybdenum, vanadium and tungsten, whose acids correspond to those of sexivalent sulphur, may here be mentioned.

The compounds thus far considered are derived from negative radicals; but, as already intimated, positive elements form a similar series of bodies. Since the equivalence of positive radicals rarely varies, but a single ortho-base of the same radical is known. Of ortho-bases, ortho-potassic base HKO, ortho-calcic base H_2CaO_2, and ortho-zirconic base H_4ZrO_4, are examples. The mineral pyrochroite is ortho-manganous base, H_2MnO_2 and brucite is ortho-magnesic base H_2MgO_2. From these, by the loss of the elements of water come the meta-bases, as meta-zirconic base H_2ZrO_3 but they are few in number. The perhydrates of the alkaline earths, so called, are probably meta-bases; as mono-meta-baric base H_2BaO_3 or $\left.\begin{matrix}(BaO)''\\H_2\end{matrix}\right\}O_2$, mono-meta-calcic base H_2CaO_3 or $\left.\begin{matrix}(CaO)''\\H_2\end{matrix}\right\}O_2$.

III. There is a third class of acids which is not included in either of the divisions above given. I refer to those which contain more than a single atom of the radical. Since they are derived from the ortho-acids, they are evidently meta-acids. The most familiar example is pyrophosphoric acid, $H_4P_2O_7$, derived from two molecules of ortho-phosphoric acid H_3PO_4 by the loss of the elements of three molecules of water, $H_{10}P_2O_{10}-(H_2O)_3=H_4P_2O_7$. A simple method of naming these acids is suggested by the principles already given. All acids derived from two molecules of phosphoric acid, for example, may be called di-phosphoric acids;† and the number of

* This Journal, II, xliv, 263, Sept. 1867.

† As has already been proposed by Wurtz (Chemical Philosophy, London, 1867, 159), Schiff (Ann. Ch. Pharm., IV. Suppl., 30), Naquet (Chimie, 2d ed. i, 172), Frankland (Lecture notes, 103), Rammelsberg (Chemie, Berlin, 1867, 292), (Weltzien, Syst. Uebers. der Silicate, Giessen, 1864,) and others, though in a modified

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molecules of water lost, to yield the meta-acid may be indicated by a numeral prefix to the meta, as above. Hence, as pyrophosphoric acid becomes tri-meta-di-phosphoric acid. A rule for naming may be given, as follows; Prefix to the name of the acid, the numeral corresponding to the number of atoms of the negative radical contained in the formula. Then add the elements of water until the oxygen and the hydrogen atoms are equal; the numeral indicating the number of molecules of water thus employed, is to be prefixed to the word meta, placed before the name of the acid. For example, Fleitmann and Henneberg obtained two soda salts, referable to the acids $H_6P_4O_{13}$ and $H_{12}P_{10}O_{31}$. The first is a tetra-phosphoric acid, the ortho-acid of which is reproduced by adding to it seven molecules of water. The second is derived from deca-phosphoric acid, by the loss of nineteen molecules of water. Hence the salts are sodic hepta-meta-tetra-phosphate and sodic enneadeca-meta-deca-phosphate; meaning that the former is derived from four molecules of the ortho-acid by the loss of seven molecules of water, and the latter is nineteen removes from ten acid molecules. These acids and their derivatives are exceedingly numerous. Wurtz is inclined to view them as accumulated bodies, similar to the polyethylenic alcohols; stating that as PbO may be added to $\left.\begin{matrix}Pb''\\H_2\end{matrix}\right\}O_2$, producing $\left.\begin{matrix}Pb''\\Pb''\\H_2\end{matrix}\right\}O_3$ and $\left.\begin{matrix}Pb''\\Pb''\\Pb''\\H_2\end{matrix}\right\}O^4$, so to $\left.\begin{matrix}(SO_2)''\\H_2\end{matrix}\right\}O_2$, $(SO_2)''O$ may be added, yielding the fuming or Nordhausen sulphuric acid $\left.\begin{matrix}(SO_2)''\\(SO_2)''\\H_2\end{matrix}\right\}O_3$ equal to $H_2S_2O_7$, our penta-meta-di-sulphuric acid. This process, however, leaves the basicity of the acid unaltered; and hence is insufficient in many cases.

The number of these acids may be illustrated by a table, showing the di- and tri-acids of the tetrad silicon, and of the pentad phosphorus, with the various meta acids derived from them, as follows:

sense. In the places above cited these authors speak of di-silicic acid, referring apparently, to any acid containing two silicon atoms. The normal di-silicic acid of these writers, however, is $H_6Si_2O_7$; whereas my di-silicic acid is $H_8Si_2O_7$, two molecules of ortho-silicic acid, from which by the loss of H_2O, is obtained $H_2Si_2O_7$, mono-meta-di-silicic acid.

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	Di-acid.		*Tri-acid.*	
	Tetrad.	*Pentad.*	*Tetrad.*	*Pentad.*
Ortho,	$H_8Si_2O_8$*	$H_{10}P_2O_{10}$*	$H_{12}Si_3O_{12}$*	$H_{15}P_3O_{15}$*
Mono-meta,	$H_6Si_2O_7$	$H_8P_2O_9$	$H_{10}Si_3O_{11}$	$H_{13}P_3O_{14}$
Di-meta,	$H_4Si_2O_6$*	$H_6P_2O_8$*	$H_8Si_3O_{10}$	$H_{11}P_3O_{13}$
Tri-meta,	$H_2Si_2O_5$	$H_4P_2O_7$	$H_6Si_3O_9$*	$H_9P_3O_{12}$*
Tetra-meta,	Si_2O_4	$H_2P_2O_6$*	$H_4Si_3O_8$	$H_7P_3O_{11}$
Penta-meta,		P_2O_5	$H_2Si_3O_7$	$H_5P_3O_{10}$
Hexa-meta,			Si_3O_6	$H_3P_3O_9$*
Hepta-meta,				$H\ P_3O_8$

A few examples of well known compounds, formed in this way, will make the preceding remarks clear.

Cupric mono-meta-di-arsenite,	$Cu_2As_2O_5$ (Scheele's green)
Plumbic tri-meta-di-arsenate,	$Pb_2As_2O_7$
Ferric tri-meta-di-sulphate,	$Fe^{vi}S_2O_9$
Potassic penta-meta-di-chromate,	$K_2Cr_2O_7$
Penta-meta-di-periodic acid,	$H_4I_2O_9$
Di-hydro-plumbic mono-meta-tri-carbonate,	$H_2Pb_4C_3O_{11}$ (white lead).
Hepta-meta-tri-iodic acid,	HI_3O_8
Plumbic tri-meta-tetra-sulphantimonite,	$Pb_3Sb_4S_9$ (Jamesonite).
Sodic penta-meta-tetra-borate,	$Na_2B_4O_7$ (borax).
Potassic ennea-meta-tetra-iodate,	$K_2I_4O_{11}$
Ennea-meta-tetra-periodic acid,	$H_{10}I_4O_{19}$
Plumbic penta-meta-hexa-sulphantimonite,	$Pb_4Sb_6S_{13}$ (plagionite).
Magnesic ennea-meta-octo-borate,	$Mg_3B_8O_{15}$ (boracite).

IV. In the formulas of these and similar substances the atoms of the negative radical are united to each other by oxygen, as Frankland has already shown for many of them.† It is evident, however, that these atoms may unite directly together, in which case two units of attraction in each pair of atoms will be occupied in uniting them. The equivalence of the group will then be represented by the law of saturation $E=S-2(n-1)$, already given. Certain artiads have a particular tendency to combine in this manner; as mercury in Hg_2Cl_2 and copper in Cu_2H_2; and particularly the iron group of metals, which were long supposed to be triads for this reason. Two atoms of a

* The compounds thus indicated are not distinct acids, but are multiples of the simple ortho or meta forms. See Wurtz' Chemical Philosophy, London, 1867, 158, note. It may here be remarked that monobasic phosphoric acid is capable of forming a series of polymeric compounds corresponding to the multiples given above. With silver, for example, $Ag_2P_2O_6$, $Ag_3P_3O_9$ and $Ag_6P_6O_{18}$ have been obtained. They are called di-, tri- and hexa-meta-phosphates, respectively. In the table, the first appears as tetra-meta-di-phosphate, and the second as hexa-meta-tri-phosphate.

† Lecture notes for chemical students, London, 1866.

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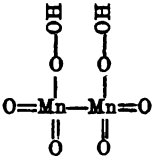
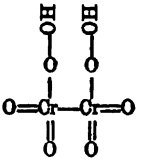
tetrad directly united, lose two bonds, and together act as a hexad. Fe_2Cl_6 or $\mathbf{Fe}^{vi}Cl_6$ $\mathbf{Mn}^{vi}O_3$, $\mathbf{Co}^{vi}S_3$, $\mathbf{Cr}^{vi}Cl_6$, etc., are examples of binaries so formed. With hydryl the compounds produced are quite numerous, and many of them occur as minerals. Thus ortho-ferric base $H_6\mathbf{Fe}^{vi}O_6$ is limonite, and ortho-aluminic base $H_6\mathbf{Al}^{vi}O_6$ is gibbsite. From these are derived the meta-bases; as from $H_6\mathbf{Al}^{vi}O_6$ comes $H_4\mathbf{Al}^{vi}O_5$ mono-meta-aluminic base, and $H_2\mathbf{Al}^{vi}O_4$ di-meta-aluminic base, diaspore. So from limonite $H_6\mathbf{Fe}^{vi}O_6$ may be obtained $H_4\mathbf{Fe}^{vi}O_5$ mono-meta-ferric base (xanthosiderite) and $H_2\mathbf{Fe}^{vi}O_4$ di-meta-ferric base (Göthite). Manganite $H_2\mathbf{Mn}^{vi}O_4$ is di-meta-manganic base. Permanganic and perchromic acids, $H_2Mn_2O_8$ and $H_2Cr_2O_8$, as was stated on page 389, must contain their radicals as heptads, if their atoms are united by oxygen. Frankland, however, to avoid a violation of the fundamental law of saturation, supposes that the manganese and chromium atoms are directly united, and makes an oxygen atom intervene between each negative atom and the hydryl, thus:—

Permanganic acid.



Perchromic acid.



On either supposition, their constitution is anomalous.

The same direct union takes place with the carbon group of tetrads forming $\mathbf{C}^{vi}Cl_6$, $\mathbf{Sn}^{vi}O_3$, $\mathbf{Ti}^{vi}N_3$, etc. With hydryl, therefore, such a series of compounds as the following, becomes possible.

	Carbon.	*Silicon.*
Ortho-oxalic acid,	$H_6\mathbf{C}^{vi}O_6$	$H_6\mathbf{Si}^{vi}O_6$
Mono-meta-oxalic acid,	$H_4\mathbf{C}^{vi}O_5$	$H_4\mathbf{Si}^{vi}O_5$
Di-meta-oxalic acid,	$H_2\mathbf{C}^{vi}O_4$	$H_2\mathbf{Si}^{vi}O_4$
Di-carbonic tri-oxyd,	$\mathbf{C}^{vi}O_3$	$\mathbf{Si}^{vi}O_3$

In the carbon series, the di-meta form is ordinary oxalic acid, from which the group may be named. The ortho-oxalic acid is represented in plumbic ortho-oxalate $Pb''_3\mathbf{C}^{vi}O_6$ but the mono-meta acid seems to be unknown. The silicon compounds do not appear to be known with certainty, although several observers have reported the discovery of a di-silicic tri-oxyd (sesquioxyd of silicon) with some of the hydrates belonging to it.

The view which has now been given, of the constitution of acids and bases, renders very simple the relation of these bodies to the chlorhydrines, so-called. An acid being converted into

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a chlorhydrine by exchanging its hydryl (HO)′ for the monad chlorine (from which fact the word chlorhydrine comes) it is evident that there may be as many chlorhydrines obtained from a given ortho or meta acid, as is equal to the number of atoms of its basic hydrogen, less one, the final product being the chlorid of the radical. Thus with ortho-silicic acid, there may be

Hydric silicate.	Mono-chlorhydrine.	Di-chlorhydrine.	Tri-chlorhydrine.	Silicic chlorid.
$HO-Si(OH)_2-OH$	$HO-Si(Cl)(OH)-OH$	$HO-Si(Cl)_2-OH$	$HO-Si(Cl)_3$	$Cl-Si(Cl)_3$

Compounds corresponding to all these chlorhydrines, have been obtained by Friedel and Crafts.* If the acid be a meta-acid, the radical is partially saturated by oxygen, and the final result is a so-called oxychlorid (the chlor-aldehyd of Odling); the true aldehyd being a similar body, containing hydrogen in place of chlorine. For example, di-meta-sulphuric acid may form in this way the following bodies:

Acid.	Mono-chlorhydrine.	Dichlor-hydrine.	Hydro-chlorhydrine.	Di-hydro-hydrine.	Mono-hydro-hydrine.
$HO-S(=O)_2-OH$	$HO-S(=O)_2-Cl$	$Cl-S(=O)_2-Cl$	$Cl-S(=O)_2-H$	$H-S(=O)_2-H$	$HO-S(=O)_2-H$

A comparison of these formulas with those of hypophosphorous and phosphorous acids on page 392, will make clear the relation of these acids to mono-meta-phosphoric acid, by showing that they are its hydro-hydrines, the last of the series, H_3PO phosphoric aldehyd, not being yet known.

The results given in the foregoing pages may be briefly recapitulated. I have attempted to show:

1. That all the bonds of any simple radical may be saturated by the monad hydryl.

2. That the compounds thus formed, are determined by the electro-chemical character of the radical; being acids when it is negative, and bases when it is positive.

3. That acids and bases so formed, being evidently normal, are conveniently designated by the prefix *ortho*.

4. That the equivalence of negative radicals varies through several stages, while that of positive rarely changes. And hence, that there may be a series of ortho acids from a given negative radical, but only a single base from a positive one.

5. That by the removal of the elements of water from a normal or ortho acid, a derived acid is produced, which may be indicated by the prefix *meta*.

* This Journal, II, xliii, 155, March, 1867.

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6. That when there are several such derivatives, the Greek numeral prefixes di, tri, tetra, etc., may be used to indicate the number of molecules of water removed from the ortho acid to yield the meta-form.

7. That intermediate between the simple ortho- and meta-acids, are others containing more than a single atom of the negative radical; and that these acids may be designated by di, tri, tetra, etc., (according to the number of negative atoms) prefixed to the name of the acid, while the number of molecules of water removed from a multiple of the normal acid to form them is indicated by the same numerals prefixed to the meta.

8. That while the negative atoms in the compounds just mentioned are united by oxygen, there may be other compounds whose negative or positive atoms are united directly; thus producing a fourth class of acids and of bases.

By classifying thus the substances known as acids and bases, —and of course the salts derived from them—it is hoped that their relations to each other may be made clearer. And by giving them systematic names, their position in the series may be fixed, and a step be taken toward the establishment of a rational nomenclature.

New Haven, Oct. 10, 1867.

ART. XLIII.—*Crystallogenic and Crystallographic Contributions; by* JAMES D. DANA. *On the Feldspar group of Minerals; supplementary to* ART. XXIX, *page* 252: *On the Chemical Formulas of the Silicates.*

1. *Chemical formulas of the Feldspars, and of some other Silicates.*

THE resemblance or affiliation between the species of the Feldspar group is of the most intimate kind. There is not merely isomorphism (or close approximation in crystalline form), which, when alone, is of little value in determining relations, but also, apparently, the profoundest *isotypism.* For the approximation includes near identity in (*a*) the habitual forms; (*b*) the direction and facility of the two cleavages; (*c*) the hardness; (*d*) the color, and tendency to opalescence; (*e*) all optical characteristics; and as regards chemical composition, they agree in consisting of silica, alumina, and an alkali or alkaline earth, to the exclusion of magnesium and iron; and the oxygen ratio between the protoxyds and sesquioxyds* is for

* The expression "oxygen ratio between the protoxyds and sesquioxyds," is equivalent, under the new system, to the ratio between the combining powers of the protoxyd or dyad and sesquioxyd or pseudotriad metals," the so-called dyad

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each 1 : 3. The group, therefore, is one in nature, and chemistry must have some explanation of this unity. The following observations bear on the question of its origin.

1. The oxygen ratios for the protoxyds, sesquioxyds, and silica, in the different Feldspars, are as follows:

	$\dot{R}$ $\dddot{Al}$ $\dddot{Si}$		$\dot{R}$ $\dddot{Al}$ $\dddot{Si}$
Anorthite	1 : 3 : 4	Oligoclase	1 : 3 : 9
Labradorite	1 : 3 : 6	Albite	1 : 3 : 12
Andesine, Hyalophane	1 : 3 : 8	Orthoclase	1 : 3 : 12

[The ratio 1 : 3 for the *basic oxyds* is expressed in the formula $\dot{R}+\dddot{Al}$, or $(\frac{1}{4}\dot{R}^3+\frac{3}{4}\dddot{Al})$; and, for the *basic metals*, in the formula $R+3\beta Al$, or $(\frac{1}{4}R+\frac{3}{4}\beta Al)$; or if the perissads are distinctly indicated, in the formula $(R, R_2)+3\beta Al$, or $(\frac{1}{4}(R, R_2)+\frac{3}{4}\beta Al)$.]

Besides the above-mentioned ratios, some analyses afford 1 : 3 : 4½, 1: 3 : 5, 1 : 3 : 5½, and other ratios between 1 : 3 : 4 and 1 : 3 : 6; and so also intermediate ratios between 1 : 3 : 6 and 1 : 3 : 8; between 1 : 3 : 8 and 1 : 3 : 9; and between 1 : 3 : 9 and 1 : 3 : 12. But these cases, (and also those in which there is some variation from the ratio 1 : 3,) are usually regarded as exceptional to the above as the true normal ratios; and they have been attributed to the following causes:

(*a*) Incorrect analyses.

(*b*) Impurities: and often mixtures of different feldspars through inter-crystallization, some remarkable examples of which have been detected by microscopic and optical examinations.

(*c*) Alteration; caused either (1) by the infiltration of ordinary waters carbonated or not—such waters filtered through powdered feldspar being known to become alkaline in a short time, and the rocks containing feldspars having been exposed to this action through long ages past; and examples being numerous of the alteration of feldspars, ending in their kaolinization, in which both alkalies and silica are lost; or (2) through the same process aided by mineral ingredients in the waters, resulting in the introduction of magnesia, oxyds of iron, etc., and in other changes.

As regards the views here presented, it matters not whether these intermediate ratios are irregularities produced by the above methods, or are normal ratios.

group here including not only Ca, Mg, Fe, etc., but also K_2, Na_2, Li_2, etc., as illustrated in the classification on p. 204 of the former paper. I use beyond the expressions of the old system, as they are intelligible to all chemical readers, whether versed in the new system or not.

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2. The oxygen ratio in Anorthite is that of a Unisilicate, for 1 + 3 : 4 = 1 : 1; and the formula may be, on the old and new system:

Old $(\frac{1}{4}\dot{R}^3+\frac{3}{4}\dddot{Al})^2\ddot{Si}^3$ New $Si|O_4|(\frac{1}{4}R_2+\frac{3}{4}\beta Al)^2$

In the other species, the oxygen ratios vary from that of Anorthite, through an increase in the proportion of silica, they being as follows:

	Bases		Silica		Bases		Silica
Labradorite	1	:	$1\frac{1}{2}$	Oligoclase	1	:	$2\frac{1}{4}$
Andesine } Hyalophane }	1	:	2	Albite	1	:	3
				Orthoclase	1	:	3

3. The silica of a Unisilicate is enough for the making of a feldspar; that is, to produce a species having that assemblage of crystalline, physical and other qualities which characterize the group. The type is therefore essentially *Unisilicate.* But while Unisilicate, it admits of increase in the proportion of silica to produce its variety of species.

4. An excess of silica above that of a Unisilicate may exist under the Unisilicate type in one of the two following conditions, and still be not an impurity.

A. It may be *basic* silica; in which case the general formula for the group would be—

Old $(\dot{R}^3,\dddot{Al},\ddot{Si}^{\frac{3}{2}})^2\ddot{Si}^3$ New $Si|O_4|(R,R_2),\beta Al,\gamma Si)_2$

and the special formulas for the species are:

Labradorite	$(\frac{1}{3}\dot{R}^3+\frac{2}{3}\dddot{Al}+\frac{1}{3}\ddot{Si}^{\frac{3}{2}})^2\ddot{Si}^3$	$Si\|O_4\|(\frac{1}{3}(R,R_2)+\frac{2}{3}\beta Al+\frac{1}{3}\gamma Si)_2$
Andesine	$(\frac{1}{8}\dot{R}^3+\frac{3}{8}\dddot{Al}+\frac{3}{8}\ddot{Si}^{\frac{3}{2}})^2\ddot{Si}^3$	$Si\|O_4\|(\frac{1}{8}(R,R_2)+\frac{3}{8}\beta Al+\frac{3}{8}\gamma Si)_2$
Oligoclase	$(\frac{2}{13}\dot{R}^3+\frac{6}{13}\dddot{Al}+\frac{5}{13}\ddot{Si}^{\frac{3}{2}})^2\ddot{Si}^3$	$Si\|O_4\|(\frac{2}{13}(R,R_2)+\frac{6}{13}\beta Al+\frac{5}{13}\gamma Si)_2$
Albite	$(\frac{1}{8}\dot{Na}^3+\frac{3}{8}\dddot{Al}+\frac{4}{8}\ddot{Si}^{\frac{3}{2}})^2\ddot{Si}^3$	$Si\|O_4\|(\frac{1}{8}Na_2+\frac{3}{8}\beta Al+\frac{4}{8}\gamma Si)_2$
Orthoclase	$(\frac{1}{8}\dot{K}^3+\frac{3}{8}\dddot{Al}+\frac{4}{8}\ddot{Si}^{\frac{3}{2}})^2\ddot{Si}^3$	$Si\|O_4\|(\frac{1}{8}K_2+\frac{3}{8}\beta Al+\frac{4}{8}\gamma Si)_2$

R (or R,R_2) in Labradorite, Andesine and Oligoclase = Ca, Na, with occasionally some K; in Hyalophane, which has the formula of Andesine, = Ba and Na; Ba replacing the Ca of other feldspars. These formulas are partially presented on page 260.

B. It may be *accessory* silica; by which is meant, not an ingredient unessential to the species, but a true component, accessory to the fundamental type of the series.* The formulas on this view would be:—

* This idea of the feldspars is recognized by the author in the last edition of his Mineralogy (1854) in which he heads the group as follows: "Type ratio for the oxygen of bases and silica 1 : 1, and varying from this by the addition of silica to the type"; and gives the following as the formulas:

Anorthite	$(\dot{R}+\dddot{Al})\ddot{Si}^{\frac{4}{3}}$	Oligoclase	$(\dot{R}+\dddot{Al})\ddot{Si}^{3}$
Andesine	$(\dot{R}+\dddot{Al})\ddot{Si}^{\frac{8}{3}}$	Albite	$(\dot{R}+\dddot{Al})\ddot{Si}^{4}$
Labradorite	$(\dot{R}+\dddot{Al})\ddot{Si}^{2}$	Orthoclase	$(\dot{R}+\dddot{Al})\ddot{Si}^{4}$

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Anorthite	$(\frac{1}{4}\dot{R}^3+\frac{3}{4}\dddot{Al})^2\ddot{Si}^3$	$Si\|O_4\|(\frac{1}{4}R+\frac{3}{4}\beta Al)_2$
Labradorite	$(\frac{1}{4}\dot{R}^3+\frac{3}{4}\dddot{Al})^2\ddot{Si}^6+\frac{3}{2}\ddot{Si}$	$Si\|O_4\|(\frac{1}{4}(R,\ R_2)+\frac{3}{4}\beta Al)_2+\frac{1}{2}SiO^2$
Andesine Hyalophane	$(\frac{1}{4}\dot{R}^3+\frac{3}{4}\dddot{Al})^2\ddot{Si}^6+3\ddot{Si}$	$Si\|O_4\|(\frac{1}{4}(R,\ R_2)+\frac{3}{4}\beta Al)_2+SiO^2$
Oligoclase	$(\frac{1}{4}\dot{R}^3+\frac{3}{4}\dddot{Al})^2\ddot{Si}^3+3\frac{1}{2}\ddot{Si}$	$Si\|O_4\|(\frac{1}{4}(R,R_2)+\frac{3}{4}\beta Al)_2+1\frac{1}{2}SiO^2$
Orthoclase Albite	$(\frac{1}{4}\dot{R}^3+\frac{3}{4}\dddot{Al})^2\ddot{S}^3+6\ddot{Si}$	$Si\|O_4\|(\frac{1}{4}R_2+\frac{3}{4}\beta Al)_2+2SiO^2$

According to either of these two methods, A or B, any other proportions of silica exceeding that of the Unisilicate may be expressed in the same manner as the above.

The last of the formulas under A, if expanded, becomes,—

Old	$(\dot{R}^3)^2\ddot{Si}^3+3\dddot{Al}^2\ddot{Si}^6+4\ddot{Si}^{\frac{3}{2}}\ddot{Si}^6$
New	$Si\|O_4\|(R_2)_2+3[Si\|O_4\|\beta Al_2]+4[Si\|O_4\|\gamma Si_2]$

in which the last member consists of silica alone; and thus the formula approaches the corresponding one under B, yet with this important difference, that the silica in this member is in the former in two states, a basic and an acid.

5. *The excess of silica above the amount required for the Unisilicate increases with the increase of the alkalies, or the perissad elements, in the base.*

In Anorthite, true unisilicate feldspar, the base consists of lime without alkalies. But in the other feldspars, with higher silica, it is partly soda or potash, with lime, or in one case (Hyalophane) baryta; or it is wholly soda or potash. The ratios of non-alkaline to alkaline constituents in the bases in these species are, for the average results of analyses, as follows:

	Non-alk. : Alk.		Non-alk. : Alk.
Labradorite	2 : 1	Oligoclase	1 : 2
Hyalophane	$1\frac{1}{3}$: 1	Orthoclase	all alkali.
Andesine	1 : 1	Albite	all alkali.

Thus the above statement is fully sustained by the average results of the analyses. Looking to special analyses, it will be found that in general those Labradorites which contain less than the normal proportion of silica (and so approach Anorthite) are those which contain *most* lime in proportion to the alkali; and those which give the oxygen ratio 1 : 3 : 6·5, 1 : 3 : 7 are those which contain *least* lime relatively to the amount of alkali; and so for the ratios between 1 : 3 : 8 and 1 : 3 : 9, and others between 1 : 3 : 9 and 1 : 3 : 12. There are exceptions to this statement, as should be expected when we consider the diversity of causes (see p. 309) which may have aided in producing these intermediate ratios. But the cases in accordance are sufficient to sustain it.

It would seem, therefore, that this excess of silica is dependent in part, if not wholly, on the alkaline or perissad nature of the base.

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There is a prominent exception to this view in the species Leucite, which, although *isometric* in crystallization, is regarded as of the Feldspar group, since it has a similar general constitution, with the Andesine ratio 1 : 3 : 8. For although it is thus related to Andesine, the protoxyd base is solely alkaline. Yet, as it stands apart in its isometric crystallization, it may not be as certainly in opposition as would at first seem. It may belong with Sodalite and Haüynite to an independent series in the group. Sodalite (with Haüynite) has the anorthite ratio 1 : 3 : 4, and is a soda species; while Leucite, with 1 : 3 : 8, is a related potash species; and if the two are in an independent series, it would appear that potash is more strongly determinative of the higher ratio of silica than soda.

6. Facts exist among other silicates that throw some light on this subject.

A. The Mica group has the following for the oxygen ratios between the bases and silica:

	Bases	Silica		Bases	Silica
1. Astrophyllite	1 :	1	5. Muscovite	1 :	$1\frac{1}{4}$
2. Phlogopite	1 :	1	6. Lepidolite	1 :	$1\frac{1}{2}$
3. Biotite	1 :	1	7. Cryophyllite	1 :	2
4. Lepidomelane	1 :	1			

Now the ratios of the non-alkaline to alkaline constituents of the protoxyd bases in these species, as deduced from the average results of analyses, are as follows:

	Non-alk.	: Alk.		Non-alk.	: Alk.
1. Astrophyllite	6	: 1	5. Muscovite	1	: 2 to 6
2. Phlogopite	6	: 1	6. Lepidolite	1	: 3 to 12
3. Biotite	3	: 1	7. Cryophyllite	almost solely alk.	
4. Lepidomelane	2–1	: 1			

The non-alkaline part of the protoxyd base in the species is mostly magnesia and protoxyd of iron, with some lime; and the alkaline, mostly potash, except in Lepidolite and Cryophyllite, which contain also lithia. The protoxyd bases are most exclusively alkaline in Cryophyllite.

The parallelism with the Feldspar group is striking; and there may be the same reason, therefore, for the increase of the silica, and not that mentioned on page 259.

B. Again, among Unisilicates, the Meionite section of the Scapolite group illustrates the same principle. The species Meionite, Mizzonite and Marialite are closely alike in crystallographic and physical qualities, so much so that Mizzonite has generally been made a variety of Meionite; and Marialite if it had been as long described would probably have shared the same fate. (It was first announced by vom Rath last year in the Zeitschr. d. deutschen geol. Ges., xviii, 635).

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The oxygen ratios, and the ratios of the non-alkaline to the alkaline portion of the protoxyd bases, are as follows:

	$\dot{R}$	$\dot{\bar{R}}$	$\dot{S}i$	$\dot{R}+\dot{\bar{R}}$	$\dot{S}i$	Non-alk.	Alk.
Meionite	1	1	2	1	1	10	1
Mizzonite	1	2	$5\frac{1}{4}$	1	$1\frac{3}{4}$	1	$1\frac{3}{4}$
Marialite	1	2	6	1	2	1	$2\frac{1}{2}$

The non-alkaline protoxyd is lime; the alkaline is soda with some potash. The excess of silica in Mizzonite and Marialite may be attributable to impurity or alteration as has been usual (and to some extent with reason) in the Scapolite division of the Scapolite group. But the crystals are glassy and show no evidence of change or mixture. They are found exclusively in volcanic or allied igneous rocks.

C. The Scapolite section of the Scapolite group affords other examples under the principle. The different compounds vary in oxygen ratio, according to the analyses, from 1 : 2 : 3·5 to 1 : 2 : 6, and from 1 : 3 : 4 to 1 : 3 : 6; and besides these there are other ratios intermediate. But Scapolite undergoes so easy alteration through the action of carbonated or alkaline waters that we have reason for doubts over many of the results of analyses.* Yet, in spite of the uncertainties from this source the principle stated comes out clearly to view. In fact it has already been remarked by Rammelsberg in his Mineral Chemie (p. 716) that "the Scapolites which are poorest in silica are richest in lime; and as the lime diminishes, the proportion of soda (or potash) increases."

Looking first at the prominent divisions, we find the following as the average ratios afforded by the best analyses.†

* Scapolite undergoes easy alteration through carbonated waters, which make the lime a carbonate; through solutions of a potash salt, which substitute potash for the soda; and through solutions of an iron salt, which introduce oxyd of iron. Vom Rath describes mica, epidote, agalmatolite, and other pseudomorphs, after scapolite. In changing to mica, potash and iron were taken up, and soda lost; to epidote, oxyd of iron (15 to 16 p. c.) was taken and part of the silica lost; to agalmatolite, potash (7 p. c.) displaced soda, and water was taken in, and moreover, part of the lime became carbonated. Similar altered scapolites have been described by others. It is rather probable that the trace of potash found in many scapolites is always a result of change.

Couzeranite has been placed near dipyre in the table on p. 404. But it contains 5·5 p. c. of potash, and is, with hardly a doubt, an altered mineral.

Eichhorn has shown (Pogg., cv. 126) that, by subjecting chabazite to the action of a cold solution of chlorid of sodium or carbonate of soda, 6 to 8 p. c. of soda may be substituted in the mineral for an equivalent of lime; and it may be that scapolite by this or other means may have its proportion of soda increased.

† The names *Wernerite* and *Scapolite* were given to Norwegian minerals from Arendal) by d'Andrada in the same article, (in Scherer's J., iv, 35, 38, 1800). *Scapolite* is needed as a name for the whole *group*, like Feldspar, Mica, Chlorite, for corresponding groups of species, and is therefore here thus employed. *Wernerite* is applied to one of the two most prominent sections; *Ekebergite* to the other, it including the variety so-called; while Haüy's name paranthine, changed to *paranthite*, is adopted for the first of the sections. The composition of the first section was long ago the supposed composition (after Laugier's analysis) of the Arendal paranthine or scapolite.

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	$\dot{R}$ $\overline{\overline{R}}$ $\overline{\overline{S}}i$	Bases : Silica	Non-alk. : Alk.
1. Paranthite	1 : 2 : 4½	1 : 1½	2¼ : 1
2. Wernerite	1 : 2 : 4	1 : 1⅓	4 : 1
3. Ekebergite	1 : 3 : 4	1 : 1	all non-alk.
4. Dipyre	1 : 2 : 6	1 : 2	1 : 1

As a fuller exposition of the facts, the ratios for the more satisfactory analyses, from which the above mean results have been deduced, are given in the table following. The numbering of the analyses in Rammelsberg's work is added for the convenience of reference.*

	$\dot{R}$ $\overline{\overline{R}}$ $\overline{\overline{S}}i$	Bases Silica	Non-alk. : Alk
A.			
1, Pargas Storgard, Nordenskiöld	1 : 2·6 : 3·6	1 : 1·00	All non-alk.
4, Tunaberg, *trl.* Walmst.	1 : 3 : 4·2	1 : 1·05	" "
3, *a* " *trl. cryst.*, Nord.	1 : 3 : 4·3	1 : 1·06	" "
3, *b* Pargas, Ersby, *cryst.* Nord.	1 : 3·1 ; 4·4	1 : 1·07	" "
7, Pargas (Ersby?) *cryst.*, Wolff	1 : 2·9 : 4·5	1 : 1·16	17 : 1
B			
8, Pargas, Ersby, v. Rath	1 : 2·5 : 4·2	1 : 1·20	6·15 : 1
9, Arendal, *mass.*, v. Rath	1 : 1·7 : 3·4	1 : 1·24	2·65 : 1
11, " *cryst.*, v. Rath	1 : 1·8 : 3·6	1 : 1·27	5·45 : 1
16, L. Baikal, *Glaucolite*, v. Rath	1 : 2·1 : 4	1 : 1·28	3·90 : 1
15, Bolton, *pink*, Wurtz	1 : 1·8 : 3·7	1 : 1·30	2·50 : 1
13, " Thomson	1 : 2·0 : 4·0	1 : 1·33	5·70 : 1
14, Drothems, *pink*, Berg.	1 : 2·0 : 4·0	1 : 1·33	4·03 : 1
22, Bolton, *pink*, Wolff	1 : 2·2 : 4·3	1 : 1·35	3·84 : 1
17, Malsjö, *blue mass.*, v. Rath	1 : 1·7 : 4·0	1 : 1·38	5·36 : 1
18, Finland, *gnh.*, Wolff	1 : 1·9 : 4	1 : 1·38	3·98 : 1
C.			
25, Malsjö, *pink*, etc., Wolff	1 : 2·1 : 4·4	1 : 1·42	1·89 : 1
24, Pargas, *Ekebergite*, Hartw.	1 : 2 : 4·3	1 : 1·43	3·05 : 1
23, Hesselkulla, mass., Wolff	1 : 2·2 : 4·5	1 : 1·44	2·45 : 1
28, Hesselkulla, Herm.	1 : 2·5 : 5·1	1 : 1·46	3 : 1
27, Arendal, Wolff	1 : 2·1 : 4·5	1 : 1·47	2·06 : 1
Arendal, Damour	1 : 2·1 : 4·7	1 : 1·50	2·35 : 1
26, Malsjö, *white*, v. Rath	1 : 2·1 : 4·6	1 : 1·50	2·28 : 1
35, Gouverneur, *cryst.*, v. Rath	1 : 2 : 5	1 : 1·65	1·24 : 1
D.			
Couzeranite, Dufrénoy	1 : 2·3 : 5·8	1 : 1·74	1·32 : 1
Dipyre, Delesse	1 : 2·0 : 5·8	1 : 1·71	1·02 : 1
Dipyre, Damour	1 : 2·2 : 6·0	1 : 1·92	1·26 : 1
Dipyre, Pisani	1 : 2·3 : 6·5	1 : 2	0·95 : 1
Prehnitoid, Blomstrand	1 : 2 : 5·7	1 : 1·89	0·80 : 1

The four groups A, B, C, D, correspond to those above named *Paranthite*, *Wernerite*, *Ekebergite*, and *Dipyre*. Analysis No. 9, of an Arendal Scapolite diverges rather widely from the mean of the group; but the specimen was probably an abnormal one in some way, as the results are quite unlike those obtained from Arendal specimens by Wolff and Damour (No.

* The analyses omitted are those which are doubtful because containing carbonate of lime; those (as No. 30 by Brewer, 38 by v. Rath, etc.) which were published as analyses of *altered* scapolites; those of little hardness, thereby evincing alteration; the analyses of glaucolite by Bergemann and Givartovski, the mineral for which v. Rath has shown is of uncertain nature, and not true glaucolite.

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27 and the one next following). With this exception, and that of Wurtz's (No. 15) which is not sustained in its exceptional character by Wolff's, (No. 22) of the same mineral, nor by a new determination by B. S. Burton, the concordances with the principle stated are close, considering the uncertainties of analyses, and the uncertain purity or condition of specimens.

D. Among the Bisilicates, occurs the species *Spodumene.* It is so closely like pyroxene in angles, and also in habit of crystals and physical characteristics, that it is rightly placed in the pyroxene group. It has the oxygen ratio for the protoxyds, sesquioxyds, and silica 1 : 4 : 10; whence 5 : 10=1 : 2 for the bases and silica, as in other Bisilicates. Its protoxyd bases are mainly alkaline, the proportion of alkaline to non-alkaline averaging 12 : 1 in the best analyses—those of Rammelsberg and Hagen (the extremes being 4 : 1 and 20 : 1), and those of Smith & Brush (which give 11 : 1 and 13 : 1). There is some iron present which is here made protoxyd as done by Rammelsberg. Descloizeaux has shown that *Petalite,* is also like pyroxene, in crystallization, and in this and other characters, approaches Spodumene. It contains, like it, silica, alumina, lithia, and soda; but the oxygen ratio is 1 : 4 : 20, the silica being doubled, as remarked by Descloizeaux. There is this other difference that the protoxyd bases are *exclusively* alkaline; no iron is present either as protoxyd or sesquioxyd. This increase of the silica by a simple ratio is evidently parallel with the same in the Feldspar and Mica groups. And since both Spodumene and Petalite occur in granitic rocks, or those of extreme metamorphism, and therefore of like heat in origin, and as the Spodumene is often imbedded in free quartz, showing that there was no lack of silica at its formation, it would appear that the small difference of constitution as to the bases, above pointed out, determines the proportion of silica. It is quite possible that iron may have the same influence as the non-alkaline metals even if it replace alumina.*

From the above examples it seems to follow, first, that under

* Another probable example under the principle is that of *Leucophane,* and the Chrysolite group. Chrysolite has a vertical prism of 94° 3′, with a macrodome of 76° 54′. Leucophane, also orthorhombic, has the corresponding angles 91° to 93°, and 72° 50′; there is, hence, approximate isomorphism. In both, moreover, the bases are all protoxyds; and as respects habit and physical characters, they may well be related species. Now Chrysolite is a normal Unisilicate, the oxygen ratio, for bases and silica being 1 : 1, and it contains no alkalies. While Leucophane has a large excess of silica, the oxygen ratio being 1 : 1⅓ instead of 1 : 1, and, *correspondingly, it contains* 10 *to* 11 *p. c. of soda.*

Again, *Meliphane* (melinophane) appears to bear the same relation in form and constitution to phenacite, as Leucophane to Chrysolite. [The name *melinophane* is wrong and bad, the Greek signifying either *ash-* or *millet-like,* instead of *honey-like* as its author intended. It should be *melitophane* or meliphane.]

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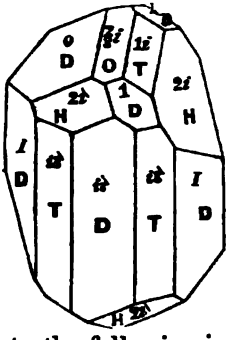
both the Unisilicate and Bisilicate type, there is some principle on which the proportion of silica may increase without changing the type; secondly, that this increase accompanies increase in the proportion of the alkalies, (or the perissad metals) and is probably more promoted by $\dot{K}$ than $\dot{Na}$; thirdly that this excess of silica occurs without a change of the type of the species from that of the Unisilicate or Bisilicate; and that the surplus silica is either accessory silica, or part of it basic.*

2. *Isomorphism of the Isometric and Clinohedral Feldspars.*

Although Leucite belongs apparently to a different series in the Feldspar group from the clinohedral (monoclinic and triclinic) species, and its trapezohedral form has seemingly very little resemblance to the oblique prisms of the other Feldspars, the monoclinic crystals of orthoclase and the triclinic of anorthite etc., are in fact nothing but distorted, or rather, *clinohedrized dodecahedrons*, variously modified by cubic, octahedral, trapezohedral and other planes.

In Orthoclase this clinohedrism consists (*a*) in giving the dodecahedron an obliquity in one direction of about 8 degrees, one of its octahedral axes, thus inclined in a vertical plane parallel to a pair of dodecahedral planes, becoming the vertical axis; and (*b*) slightly shortening this axis; and for the triclinic forms, it is nearly the same, excepting that the obliquity extends to the vertical plane referred to, and consequently to the planes about it.



The annexed figure represents a common form of Orthoclase, copied from Naumann's crystallography. The lettering corresponds to the following in Naumann, and Brooke and Miller:

Naumann	*O*	*I*	*i-i*	*i-3'*	*¾-i*	*1-i*	*2-i*	*1*	*2-i*
	0P	∞P	[∞P∞]	[∞P3]	¾P∞	P∞	2P∞	P	[P∞]
	P	*T, l*	*M*	*z*	*q*	*x*	*y*	*o*	*n*
Brooke & Miller	001	110	010	130	203	101	201	111	021
	c	*m*	*b*	*z*	*q*	*x*	*y*	*o*	*n*

The prismatic angle of the crystals is 118° 48′ or near 120°; and the same angle in Albite is 120° 47′; in Oligoclase 120° 42′; in Labradorite 121° 37′; in Anorthite 120° 30′.

* *Errata.*—In these articles, this volume, p. 93, 14 l. fr. foot, for $\frac{1}{3}$ read $\frac{2}{3}$; 10 l. and 13 l. fr. foot, for *δ* read *ε*, and for *ε* read *δ*. Page 253, for RO^5 read R^2O^5; for $5R^{\frac{1}{3}}O$ read $5R^{\frac{2}{3}}O$; for $R_{\frac{1}{3}}$, $R_{\frac{1}{4}}$, $R_{\frac{1}{5}}$, read $R_{\frac{1}{4}}$, $R_{\frac{2}{5}}$, $R_{\frac{1}{4}}$; for *δ* read *ε*, and for *ε* read *δ*. Page 255, 9 l. fr. foot, p. 258, 8 l. fr. top, p. 259, 2 l. fr. top, for *δ* read *ε*.

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In order to appreciate the following comparisons, the reader should have before him a dodecahedral crystal, (of garnet, for example,) or a model of the form, placed with a trihedral angle at top, and with one face of the trihedral pyramid sloping to the left; in which position it is a 6-sided prism with trihedral summits, with its planes parallel to those of the figure.

The prismatic angle of the feldspars, as in many other minerals, is very closely the angle of the dodecahedron (120°); and the four planes *I* enclosing it correspond therefore to four of the vertical faces of this dodecahedron; while the two planes *i*-*ì* which make angles with *I* of 120° 26′, are the other two.

The basal plane *O* is another dodecahedric plane; for *O* : *I* =122° 16′; and O : *i*-*ì*=90°, the exact dodecahedral angle. This makes *eight* out of the twelve.

The four planes 1, are also dodecahedric. This might be inferred from their position as referred to a model dodecahedron. It is also apparent in the angles which the planes make with one another and with the planes just shown to be dodecahedric, namely *O*, *I*, and *i*-*ì*; for 1 : 1=126° 14′, *O* : 1=124° 42′, *i*-*ì* : 1=116° 53′, the mean of which is nearly 120°. The divergence from 120° is due to the 8° of obliquity which the dodecahedral form has in orthoclase. Thus *all the twelve faces of the dodecahedron* exist on the crystal of orthoclase in the figure here presented. They are lettered **D**.

Moreover the *cleavage* in orthoclase according to this result is dodecahedric, it being parallel to *O* and *i*-*ì*, which planes are at right angles both in orthoclase and the dodecahedron.

The plane *i*-3′ replaces an edge between *I* (**D**) and *i*-*ì* (**D**); making the angle =*i*-*ì* : *i*-3′=150° 35′. The planes *i*-3′ are therefore those of the *trapezohedron* 2-2, which truncate the edges of the dodecahedron, and make with the dodecahedral planes the angle 150°; they are therefore lettered **T**. The plane 1-*i* truncates the edge between 1 and 1, other planes **D** (dodecahedric), and therefore this also is a trapezohedric plane, and is lettered **T**; it makes with each plane 1 the angle 153° 7′ (which is near 150°); and with O (**D**), over the plane ⅔-*i*(**O**), the angle 129° 41′, the corresponding isometric angle being 125° 16′. The crystal therefore contains six faces of the trapezohedron 2-2.

Again 2-*ì* are faces of the cube (or hexahedron), and are therefore lettered **H**; the angle *O* (**D**) : 2-*ì*=135° 3′ while the corresponding isometric angle is 135° Referred to the model dodecahedron, it truncates the tetrahedral solid angles. Again 2-*i* has the position of a plane truncating another tetrahedral solid angle of the dodecahedron, and is also a face of a cube, and is lettered **H**. The angle *I* (**D**) : 2-*i*=134° 19′ or very nearly

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135° the angle between a face of a cube and a plane truncating its edges.

The plane $\frac{2}{3}$-*i*, at the top of the figure, the only remaining one, is a face of the *octahedron*,—a plane which on the dodecahedron truncates its trihedral solid angles,—and it is therefore lettered **O**. The angle *I* (**D**) : $\frac{2}{3}$-*i*=145° 47′, while the angle between a dodecahedral and octahedral plane, is 144° 44′. The angle 2-*i* (**H**) : $\frac{2}{3}$-*i*=124° 51′, while the angle between a cubic and octahedral plane is 125° 16′. That the plane is octahedric is further apparent from the parallel intersections of $\frac{2}{3}$-*i*, 2-ì, *i*-3ˈ, and of *O*, $\frac{2}{3}$-*i*, 2-*i*; for (1) a cubic face makes parallel intersections between an octahedral on one side (the trapezohedral on that side being absent) and a trapezohedral on the other; and (2) an octahedral face makes parallel intersections with a cubic on one side and a dodecahedral on the other.

The form of orthoclase is therefore strictly a clinohedrized dodecahedron. The faces present in the crystal here considered, are

The *dodecahedric*, *I*, *I*, *i*-ì, *O*, 1, 1, with their opposites, or *the whole twelve.*

The *trapezohedric*, 1-*i*, *i*-3ˈ, *i*-3ˈ, with their opposites, or *six* in all.

The *octahedric*, $\frac{2}{3}$-*i*, with its opposite, or *two.*

The *cubic*, 2-ì, 2-ì, 2-*i*, with their opposites, or *the whole six.* The angles of this oblique or clinohedrized cube are 2-ì : 2-ì over *O* =90° 6′, 2-ì : 2-*i*=96° 48′.

The true or normal apex of the orthoclase dodecahedron is that part of the crystal occupied by the octahedric plane $\frac{2}{3}$-*i*; and the true obliquity of the crystal (or angle C,) instead of being 63° 53′ and 116° 7′ (or the angle *O* : *i*-*i*) would be the angle $\frac{2}{3}$-*i* : *i*-*i*, which equals 81° 54′ and 98° 06′. Hence 8° 6′ is the extent to which the octahedron has been clinohedrized in its conversion into the form of orthoclase.

For the triclinic feldspars, the only peculiarity is that already mentioned,—the fact of lateral obliquity of the principle section, so that the two cleavage planes O, *i*-ì (dodecahedric planes on opposite sides of a tetrahedral solid angle) make with one another an angle of 93° 15′ to 94° 15′ instead of 90°. The form of the crystals are so similar to those of orthoclase, with this exception, that special explanations are unnecessary.

G. Rose, in a recent article on Albite (Pogg., cxxv, p. 457), observes (p. 466), that it is a remarkable fact that the planes 2-ĭ situated either side of *O*, between it and *i*-ĭ, (planes *e* and *n* of Rose,) make with one another in albite very nearly a right angle, 90° 35′ according to Neumann, and 90° 4′ according to DesCloizeaux's measurements. It is not so surprising

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when it is understood that the two planes 2-$\bar{\imath}$ in albite are *cubic* faces.

In addition to the above dodecahedric characteristics of the crystals of the Feldspar group, it may be added that the twins are twinned parallel either to dodecahedric or cubic faces. The most common in orthoclase are those parallel to i-$\bar{\imath}$, dodecahedric; others are twinned parallel to O, also dodecahedric; others parallel to 2-$\bar{\imath}$, or a cubic face. And there are no other directions of twinning among the *triclinic* feldspars.

In another number of this Journal I propose to consider further the isometric relations of the various systems of crystallization, a subject partly elucidated in the last edition of my Mineralogy (1854, vol. i, pp. 196–204), and also in this Journal for the same year, vols. xvii, and xviii.

ART. XLV.—*On certain points in the theory of Atomicities;* by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

IN the application of the theory of atomicities to the explanation of the formation and structure of compound bodies two distinct views are held by chemists. While Kekulé and his followers maintain that the primary or essential atomicity of each element is invariable, Wurtz, Frankland and others admit that an element may have more than one degree of saturating power, Wurtz in particular assigning no specific maximum or limit in any case. The chemists of both these schools distinguish between atomic and molecular combinations, differing only as to what combinations are to be regarded as molecular. Thus according to Kekulé pentachlorid of phosphorus is a molecular compound, $P^{III}Cl_3+Cl_2$, while upon the other view it is atomic and has the formula $P^{V}Cl_5$. All chemists appear to admit that water of crystallization is in molecular and not in atomic combination.

To this view it may be reasonably objected that it creates two distinct species of chemical affinity, for if phosphorus in the terchlorid is saturated and its three units of affinity satisfied, a new force must be called in to bind the two additional atoms of chlorine which are to form the pentachlorid, and if chlorid of sodium be a saturated atomic combination, by what force does it unite with two atoms of water to form $NaCl+2H_2\Theta$? The line which this theory draws between molecular and atomic combinations is, moreover, a purely arbitrary one, as is clearly seen in the case of the chlorids of phosphorus cited above. In

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the present paper I shall endeavor to show that the assumption of a particular class of molecular compounds is unnecessary, and that all compounds may be regarded as essentially atomic. I adopt the following postulates no one of which is new.

1. The elements may be divided into two classes; those whose primary or inherent atomicities are represented by odd, and those whose atomicities are represented by even numbers.

2. The atomicities are variable and no maximum or limit can be assigned in any case. Any element of the first class may therefore be 1, 3, 5, 7, &c., atomic, and any element of the second class 2, 4, 6, 8, &c., atomic.

3. In the combinations of an element with itself or with another element a certain number of units of atomicity disappear. The atomicity of the resulting compound will be termed *secondary*.

For the sake of convenience I shall give the name of *determinant* to the dominant element in any compound, the other elements being termed *sub-determinants* or *subjects*, while the compound itself is termed the *resultant*. Thus in ammonia, $N\left\{\begin{matrix}H\\H,\\H\end{matrix}\right.$ nitrogen is the determinant, and hydrogen the subject, while in nitrid of copper, $N_2\left\{\begin{matrix}Cu\\Cu,\\Cu\end{matrix}\right.$ copper is the sub-determinant. In borid of nitrogen, $B^{III}N^{III}$, either element may be taken as the determinant. According to this view ammonia may be regarded as the product of a single action, that, namely, of nitrogen upon hydrogen, while in nitrid of copper there are two actions, the duplication of the atom of nitrogen being due to the diatomic character of the copper.

If now we consider first the case of water, OH_2, it is easy to see that if oxygen be regarded as tetratomic or at least as having an even atomicity higher than 2, water will itself be weakly diatomic, whatever may be the number of atoms of this body in a given compound. For in $O^{IV}H_2$ it is clear that only two units of affinity are saturated. Morever, in any number of atoms of water two units will vanish for every atom with the exception of the first and last, in each of which one unit only will disappear. Graphically this may be represented as follows:

—○—○—○—○—○—○—

From this it appears that the atomicity of the water of crystallization in a salt may always be considered as 2, whatever be the number of atoms. In like manner it is easily seen that ammonia, $N^{V}H_3$, is diatomic, and that any number of associated atoms of ammonia will still, as a whole, represent only a single diatomic atom.

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With these preliminaries I shall consider in order a few cases of what is termed molecular union.

Since sodium may be regarded as feebly triatomic it follows that in chlorid of sodium, $Na^{III}Cl$, there are still two units of affinity unsaturated, the intensity of the affinity being very small. Hence the salt, $Na^{III}Cl+(2\Theta H_2)''$, in which the sodium may be regarded as saturated, exists only at low temperatures. In sodic sulphate we may for convenience take sulphur as the determinant, in which case the salt will have the formula, $S^{IV}\left\{\begin{matrix}\Theta_2\\(Na\Theta)_2\end{matrix}\right.$ considered as anhydrous. But the crystallized salt contains ten atoms of water and may be written $S^{VI}\left\{\begin{matrix}\Theta_2\\(Na\Theta)'_2\\(\Theta H_2)''_{10}\end{matrix}\right.$ to exhibit the manner in which the water of crystallization completes the saturation of the hexatomic sulphur.

Trisodic ortho-phosphate contains twelve atoms of water, and if we take phosphorus as the determinant may be written

$$P^{VII}\left\{\begin{matrix}\Theta^{II}\\(Na\Theta)_3\\(\Theta H)''_{12}\end{matrix}\right.$$

phosphorus being heptatomic.

These formulas will suffice to exhibit the application of the theory to cases in which water of crystallization is present. To avoid complication in expression it would perhaps be more convenient to indicate the subordinate atomicity by Roman numerals placed beneath the symbol of the determinant and to connect the water of crystallization in the usual manner by the sign +. Thus sodic sulphate may be written

$$\begin{matrix}IV\\S\\II\end{matrix}\left\{\begin{matrix}\Theta_2\\(Na\Theta)_2\end{matrix}\right. +10aq$$

which exhibits at once both degrees of atomicity.

The views above explained enable us to formulate as atomic compounds the very numerous class of so-called double haloid salts usually regarded as molecular. Thus acid fluorid of potassium, $KF+HF$, becomes

$$\left.\begin{matrix}K^{III}F_2\\H\end{matrix}\right\} \text{ or } K\,(H^{III}F_2)$$

which may be compared directly with hydrate of potash

$$\left.\begin{matrix}K^{III}\Theta^{II}\\H\end{matrix}\right\} \text{ or } K(H^{III}\Theta).$$

The so-called double fluorids of tin, zirconium and silicon may readily be reduced to the following types in which in each case the tetratomic element is taken as the determinant.

SnF_4+2KF $\qquad Sn\left\{\begin{matrix}F_2\\(KF_2)_2\end{matrix}\right.$

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$SnF_4+3KF+HF$, $Sn\left\{\begin{matrix}3(KF_2)\\(HF_2)\end{matrix}\right.$,

ZrF_4+3CuF, $\begin{matrix}''Zr^{iv}\\''Zr^{iv}\end{matrix}\left\{\begin{matrix}3(CuF_4)''\end{matrix}\right.$

SnF_4+4NH_4F $Sn\left\{\begin{matrix}4(NH_4F_2)\end{matrix}\right.$

SnF^4+BaF $Sn\left\{\begin{matrix}F_2\\(Ba^{vi}F_4)''\end{matrix}\right.$

$2ZrF_4+2KF+NiF_2'$ $\begin{matrix}''Z^{iv}r\\Z^{iv}r\end{matrix}\left\{\begin{matrix}(KF_2)''_2(NiF_4)''\end{matrix}\right.$

ZrF_4+2NiF_2 $Zr\left\{\begin{matrix}2(NiF_4)''\end{matrix}\right.$

$2ZrF_4+5NaF$ $\begin{matrix}''Zr^{vi}\\''Zr^{vi}\end{matrix}\left\{\begin{matrix}(NaF_2)_5(F)_2\end{matrix}\right.$ ZrF_4+4KF $Zr\left\{\begin{matrix}(KF_2)_4\end{matrix}\right.$

ZrF_4+3KF $Zr\left\{\begin{matrix}(KF_2)_2\\F\end{matrix}\right.$ SiF_4+2KF $Sn\left\{\begin{matrix}(KF_2)_2\\F_2\end{matrix}\right.$

ZrF_4+KF $Zr\left\{\begin{matrix}(KF_2)\\F_2\end{matrix}\right.$

The compounds of the fluorids of tantalum, niobium, arsenic and antimony with other fluorids may be reduced to the following types, taking the pentatomic element as the determinant, and as before omitting water of crystallization for the sake of simplicity.*

TaF_5+2KF $Ta\left\{\begin{matrix}F_2\\(KF_2)_2\end{matrix}\right.$ $Nb\Theta_2F_3+2KF$ $Nb\left\{\begin{matrix}\Theta\\F\\(KF_2)_2\end{matrix}\right.$

NbF_5+2KF $Nb\left\{\begin{matrix}F_3\\(KF_2)_2\end{matrix}\right.$ $Nb\Theta_4F_3+3KF$ $Nb\left\{\begin{matrix}\Theta\\(KF_2)_3\end{matrix}\right.$

$Nb\Theta F_3+3KF+HF$ $Nb\left\{\begin{matrix}F\\(H\Theta)\\(KF_2)_3\end{matrix}\right.$

$3Nb\Theta F_3+5KF$ $\begin{matrix}''Nb^{vii}\\''Nb^{vii}\\''Nb^{vii}\end{matrix}\left\{\begin{matrix}\Theta_3(KF_2)_5F_4\end{matrix}\right.$

$3Nb\Theta F_3+4KF$ $\begin{matrix}''Nb^{vii}\\''Nb^{vii}\\''Nb^{vii}\end{matrix}\left\{\begin{matrix}\Theta_3(KF_2)_4F_5\end{matrix}\right.$

$Nb\Theta F_3+ZnF_2$ $Nb\left\{\begin{matrix}\Theta\\F\\(ZnF_4)''\end{matrix}\right.$

SbF_5, KF, $Sb\left\{\begin{matrix}F_4\\(KF_2)'\end{matrix}\right.$, $SbF_5, 2KF$, $Sb\left\{\begin{matrix}F_3\\(KF_2)_2\end{matrix}\right.$

* It must be remarked that in the comparative formulas given above the symbols of the elements in the expressions on the left hand usually, when not barred, signify the old equivalent, while in those on the right they signify atoms. The want of type for all the barred letters is the occasion of this confusion which I hope will be excused.

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$$SbOF_3,\ NaF, Sb\left\{\begin{matrix}O\\(NaF_2)\\F_2\end{matrix}\right.,\ As_2OF_8,\ 4KF,\ \begin{matrix}''As^{vii}\\''As^{vii}\end{matrix}\left\{(KF_2)_4OF_4\right.$$

Finally the two remarkable salts discovered by Briegleb and which are represented empirically by the formulas

$$PO_4Na_3+NaF+12aq \text{ and } AsO_4Na_3+NaF+12aq$$

may at once be reduced to the normal pentatomic type as follows:

$$P^v\left\{\begin{matrix}(NaO)_4\\F\end{matrix}\right.+12aq, \text{ and } A^vs\left\{\begin{matrix}(NaO)_4\\F\end{matrix}\right.+12aq.$$

It is to be remarked that in two of the above formulas, niobium, and in one arsenic, is represented as heptatomic. In these cases each atom of niobium, or of arsenic, loses two units of affinity in combining with an associate atom of the same elements. The notation employed in this and similar cases is that of Frankland.

From the double fluorids so-called, I pass to the consideration of the double chlorids, which, as is well known, are very numerous.

A glance at the following formulas will show the application of the principles which I have laid down to this class of compounds.

$$HgCl_2+MnCl_2 \qquad Hg^{ii}\left\{(Mn^{vi}Cl_4)''\right.$$

$$2HgCl_2+BaCl_2 \qquad \begin{matrix}''Hg^{iv}\\''Hg^{iv}\end{matrix}\left\{Ba^{vi}Cl_4)''(Cl)_2\right.$$

$$5HgCl_2+CaCl_2 \qquad \left.\begin{matrix}''Hg^{iv}\\''Hg^{iv}\\''Hg^{iv}\\''Hg^{iv}\\''Hg^{iv}\end{matrix}\right\}(CaCl_4)''Cl_8$$

$$2KCl+HgCl_2 \qquad Hg^{ii}(KCl_2)_2$$

$$KCl+HgCl_2 \qquad Hg^{ii}(KCl_2)Cl$$

$$KCl+2HgCl_2 \qquad \begin{matrix}''Hg^{iv}\\''Hg^{iv}\end{matrix}\left\{\begin{matrix}(KCl_2)\\Cl_2\end{matrix}\right.$$

$$MgCl_2+3HgCl_2 \qquad \left.\begin{matrix}''Hg^{iv}\\''Hg^{iv}\\''Hg^{iv}\end{matrix}\right\}(MgCl_4)''Cl_4$$

$$PtCl_4+2KCl \qquad Pt\left\{\begin{matrix}Cl_2\\(KCl_2)_2\end{matrix}\right.$$

$$PtCl_4+BaCl_2 \qquad Pt\left\{\begin{matrix}Cl_2\\(BaCl_4)''\end{matrix}\right.$$

$$PtI_4+2HI \qquad Pt\left\{\begin{matrix}I_2\\(HI_2)_2\end{matrix}\right.$$

$$Ir_2Cl_6+4KCl \qquad \begin{matrix}'Ir^{iv}\\'Ir^{iv}\end{matrix}\left\{(KCl_2)_4Cl_2\right.$$

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$$Ir_2'Cl_6+6KCl \qquad \left.\begin{matrix}'Ir^{iv}_2\\ 'Ir^{iv}_2\end{matrix}\right\}(KCl_2)_6$$

$$U_2\Theta_2Cl_2+2KCl \qquad \left.\begin{matrix}''U^{iv}\\ ''U^{iv}\end{matrix}\right\}\begin{matrix}\Theta_2\\ (KCl_2)_2\end{matrix}$$

$$AuCl_3+KCl \qquad Au^{iv}\left\{\begin{matrix}Cl_2\\ (KCl_2)\end{matrix}\right.$$

$$2AuCl_3+BaCl_2 \qquad \left.\begin{matrix}''Au^{v}\\ ''Au^{v}\end{matrix}\right\}\begin{matrix}Cl_4\\ (BaCl_4)''\end{matrix}$$

$$W\Theta_4K_2+WF_8K_2 \qquad W^{vi}\left\{\begin{matrix}\Theta_2\\ (KF_2)_2\end{matrix}\right. \quad \text{like} \quad W^{vi}\left\{\begin{matrix}\Theta_2\\ (K\Theta)_2\end{matrix}\right.$$

$$W\Theta_2F_3K \qquad W^{vi}\left\{\begin{matrix}\Theta_2\\ F\\ (KF_2)\end{matrix}\right.$$

$$W\Theta_2\text{Ꞓ}uF_4 \qquad W^{vi}\left\{\begin{matrix}(\text{Ꞓ}u\Theta_2)''\\ F_4\end{matrix}\right.$$

$$W\Theta_2\text{Ꞓ}uF_4+NH_4F \qquad W^{vi}\left\{\begin{matrix}(\text{Ꞓ}u\Theta_2)''\\ (NH_4.F_2)\\ F_3\end{matrix}\right.$$

The principle of variable atomicity enables us also to formulate a great variety of other compounds which have hitherto been considered as molecular. As the application is sufficiently evident after what has been said, I shall content myself with a few examples only.

All combinations of metallic chlorids, &c., with ammonia may be formulated atomistically if it be admitted that *n* atoms of ammonia are as a whole simply diatomic. Thus we have

$$TiCl_4+4NH_3 \qquad Ti^{vi}\left\{\begin{matrix}Cl_4\\ (4NH_3)''\end{matrix}\right.$$

Chlor. of Roseocobalt, $\text{Ꞓ}o_2Cl_6+10NH_3 \qquad \left.\begin{matrix}''\text{Ꞓ}o^{vi}\\ ''\text{Ꞓ}o^{vi}\end{matrix}\right\}Cl_6(10NH_3)''$

Chlor. of Luteocobalt, $\text{Ꞓ}o_2Cl_6+12NH_3 \qquad \left.\begin{matrix}''\text{Ꞓ}o^{vi}\\ ''\text{Ꞓ}o^{vi}\end{matrix}\right\}Cl_6(12NH_3)''$

$\left\{\begin{matrix}\text{Chlor. of}\\ \text{Xanthocob't,}\end{matrix}\right.$ $\text{Ꞓ}o_2\Theta Cl_2+N_2\Theta_3+10NH_3 \qquad \left.\begin{matrix}''\text{Ꞓ}o^{vi}\\ ''\text{Ꞓ}o^{vi}\end{matrix}\right\}\Theta_2Cl_2(N_2\Theta_3.10NH_3)''$

$\left\{\begin{matrix}\text{Sulph. of}\\ \text{Roseocobalt,}\end{matrix}\right.$ $\text{Ꞓ}o_2(S\Theta_4)_3+10NH_3 \qquad \left.\begin{matrix}''\text{Ꞓ}o^{vi}\\ ''\text{Ꞓ}o^{vi}\end{matrix}\right\}(S\Theta_4)''_3(10NH_3)''$

$\left\{\begin{matrix}\text{Sulph. of}\\ \text{Luteocobalt,}\end{matrix}\right.$ $\text{Ꞓ}o_2(S\Theta_4)_3+12NH_3 \qquad \left.\begin{matrix}''\text{Ꞓ}o^{vi}\\ ''\text{Ꞓ}o^{vi}\end{matrix}\right\}(S\Theta_4)''_3(12NH_3)''$

$\left\{\begin{matrix}\text{Sulph. of}\\ \text{Xanthocob't,}\end{matrix}\right.$ $\text{Ꞓ}o_2(S\Theta_4)_2+N_2\Theta_3+10NH_3 \qquad \left.\begin{matrix}''\text{Ꞓ}o^{vi}\\ ''\text{Ꞓ}o^{vi}\end{matrix}\right\}\begin{matrix}\Theta''(S\Theta_4)''_3\\ (N_2\Theta_3.10NH_3)''\end{matrix}$

Gros' base, $PtCl_2N_4H_{12}\Theta \qquad Pt^{vi}\{Cl_2(4NH_3)''\Theta''$

Reiset's base No. 1, $PtN_4H_{12}\Theta \qquad Pt^{iv}\{(4NH_3)''\Theta''$

" " No. 2, $PtN_2H_6\Theta \qquad Pt^{iv}\{(2NH_3)''\Theta''$

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Raewsky's base No. 1, $Pt_2Cl_2\Theta_3H_{24}\Theta_2N_8$ $\left.\begin{matrix}'Pt^{iv}\\'Pt^{iv}\end{matrix}\right\}Cl_2\Theta_5(8NH_3)''$

" " No. 2, $Pt_2Cl_4\Theta_4H_{24}\Theta_2N_8$ $\left.\begin{matrix}''Pt^{vi}\\''Pt^{vi}\end{matrix}\right\}Cl_4\Theta_6(8NH_3)''$

If it be objected to the assumption that potassium, sodium, &c., are triatomic in certain combinations, that these elements have not yet been observed to form compounds with chlorine and other usually monatomic elements of the form $K\left\{\begin{matrix}Cl\\Cl\\Cl\end{matrix}\right.$, I reply first that thallium, which unquestionably belongs to the alkaline group, is distinctly triatomic in $TlCl_3$, and secondly that if chlorine itself be sometimes triatomic, the compound KCl may be represented as $K^{III}Cl^{III}$ as well as $K^{I}Cl^{I}$, each element being saturated upon either view. With respect to the elements belonging to the nitrogen group I will simply call attention to the fact that nitrogen is heptatomic in the hyperiodids of certain complex ammoniums and enneatomic in others. Thus we have

$$N\left\{\begin{matrix}(\text{Є}H_3)_4\\I_3\end{matrix}\right., \quad \text{and} \quad N\left\{\begin{matrix}(\text{Є}H_3)_4\\I_5\end{matrix}\right.,$$

so that nitrogen furnishes the most complete series of atomicities, being 1, 3, 5, 7 and 9-atomic.

It is easily seen that there is a marked difference between the elements both of odd and of even atomicities as regards the maximum intensity of combining power. Thus potassium, sodium, hydrogen, chlorine and some other elements have their maximum of affinity with an atomicity of unity, the affinity being very much less for an atomicity of three and insensible for higher atomicities. Nitrogen, phosphorus, boron and several others have an insensible affinity for an atomicity of unity; the intensity of their affinity becomes a maximum when they are triatomic, diminishes materially when they become pentatomic, and becomes nearly insensible when they are heptatomic. Finally, tantalum and niobium have their maximum intensity of combining power with an atomicity of five. Precisely analogous differences occur with the elements of even atomicity. We are not yet in a position to determine whether the combination of two or more atoms of water, of ammonia, or in general of any compound, is accompanied by a gain or loss of combining power. In other words we do not know whether $(n\Theta H_2)''$, for example, has more or less potential chemical energy than $(\Theta H_2)''$. But we have, as I think, a right to infer that the number of atoms of water of crystallization in a salt is determined by the residual unsaturated units of affinity in the determinants of the salt itself, and will always be, for given circumstances, such as will saturate those determinants most

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nearly. Thus it is conceivable that at one temperature a salt may crystallize with two, and at another with four atoms of water, the whole quantity of water being in each case diatomic, but exerting different intensities of affinity. The same principle will apply to ammonia and other compounds.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On a new class of homologues of cyanhydric acid.*—Prof. A. W. Hofmann has communicated to the Academy of Sciences a very interesting and important memoir on a class of cyanids isomeric with the so-called nitriles but possessing very different properties. Cyanhydric acid, as is well known, under the influence of water takes up the elements of that body and forms ammonia and formic acid, the reaction being represented by the equation

$$\text{CNH}+2\text{H}_2\text{O}=\text{CH}_2\text{O}_2+\text{NH}_3.$$

Under the same circumstances the cyanids of the alcohol-radicals may yield one or the other of two different reactions. Thus in the case of cyanid of methyl we might have

$$1.\quad \underset{\text{Cyanid of methyl.}}{\text{CNCH}_3}+\underset{\text{Water.}}{2\text{H}_2\text{O}}=\underset{\text{Acetic acid.}}{\text{C}_2\text{H}_4\text{O}_2}+\underset{\text{Ammonia.}}{\text{NH}_3}$$

or

$$2.\quad \underset{\text{Cyanid of methyl.}}{\text{CNCH}_3}+\underset{\text{Water.}}{2\text{H}_2\text{O}}=\underset{\text{Formic acid.}}{\text{CH}_2\text{O}_2}+\underset{\text{Methylamine.}}{\text{NH}_2\text{CH}_3}$$

Examples of the first mode of reaction have long been known, but bodies exhibiting the second mode of reaction have not hitherto been observed. When chloroform and ammonia are heated together under pressure chlorhydric and cyanhydric acids are formed the reaction being expressed by the equation

$$\text{CHCl}_3+\text{NH}_3=3\text{HCl}+\text{CNH}.$$

Dr. Hofmann showed that this reaction takes place easily at a boiling heat when caustic potash is added to the alcoholic solution of ammonia and chloroform. On repeating this experiment with aniline instead of ammonia, Dr. Hofmann found that an oily liquid is found which passes over, on distilling the mixture, mixed with aniline. The aniline is removed by oxalic acid and the oil dried by caustic potash and distilled. It is a liquid which is green by transmitted and blue by reflected light. Its formula is $\text{C}_7\text{H}_5\text{N}$, and it is therefore isomeric with benzonitrile. The formation of this body is represented by the equation

$$\text{C}_6\text{H}_7\text{N}+\text{CHCl}_3=\text{C}_7\text{H}_5\text{N}+3\text{HCl}.$$

Dr. Hofmann calls this substance cyanid of phenyl; its physical properties are entirely different from those of benzonitrile; it unites directly with metallic cyanids, even with cyanid of silver, and by taking up water forms aniline and formic acid—

$$\text{C}_7\text{H}_5 . \text{N}+2\text{H}_2\text{O}=\text{C}_6\text{H}_5\text{H}_2\text{N}+\text{CH}_2\text{O}_2.$$

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It is remarkable that while the nitrids are easily decomposed by boiling alkaline solutions cyanid of phenyl is scarcely altered by these but is hydrated by the action of dilute acids.

When benzonitrile is converted into benzoic acid benzamid is formed as an intermediate product

$$\mathrm{C_7H_5N + H_2O = \underset{\text{Benzamid.}}{C_7H_7NO}}.$$

When cyanid of phenyl forms aniline and formic acid phenyl-formamid is formed as an intermediate product

$$\mathrm{C_7H_5N + H_2O = \underset{\text{Phenyl-formamid.}}{C_7H_7NO}}$$

But in this case another intermediate product is formed which is methenyl-diphenyl-diamine, formerly discovered by Hofmann. Ethylamine, amylamine and toluidine yield new cyanids by a similar reaction. The difference between the nitriles and the new cyanids may be explained by referring them to different types. Thus in the case of the two cyanids of methyl we have

$$\underset{\text{Hofmann's isocyanid.}}{\mathrm{N}\left\{\begin{matrix}\mathrm{C^{ii}}\\ \mathrm{CH_3}\end{matrix}\right.} \qquad \underset{\text{Acetonitrile.}}{\mathrm{C^{iv}}\left\{\begin{matrix}\mathrm{N^{iii}}\\ \mathrm{CH_3}\end{matrix}\right.}$$

To explain the relations of these substances to water we have the equations

$$\underset{\text{Isocyanid.}}{\mathrm{N}\left\{\begin{matrix}\mathrm{C^{ii}}\\ \mathrm{CH_3}\end{matrix}\right.} + \mathrm{2H_2O} = \underset{\text{Methylamine.}}{\mathrm{N}\left\{\begin{matrix}\mathrm{H_2}\\ \mathrm{CH_3}\end{matrix}\right.} + \underset{\text{Formic acid.}}{\mathrm{CH_2O_2}}$$

$$\underset{\text{Acetonitrile.}}{\mathrm{C^{iv}}\left\{\begin{matrix}\mathrm{N^{iii}}\\ \mathrm{CH_3}\end{matrix}\right.} + \mathrm{2H_2O} = \underset{\text{Acetic acid.}}{\mathrm{C^{iv}}\left\{\begin{matrix}\mathrm{CH_3}\\ \mathrm{O^{ii}}\\ \mathrm{OH}\end{matrix}\right.} + \mathrm{NH_3}.$$

In the same manner we easily explain the difference between the cyanetholine of Cloez and ordinary cyanic ether, and recognize in general the existence of two parallel series of cyanogen compounds. In two later communications, Dr. Hofmann has given further details of his very interesting investigation. When an alcoholic solution of ethylamine and chloroform is gradually poured into a retort containing caustic potash a violent reaction ensues, and among the products of the distillation cyanid of ethyl is formed as a liquid possessing an intolerably penetrating odor. The author has not yet carefully studied this body but gives a more detailed account of the cyanid of amyl. This last as obtained by a similar reaction is a colorless liquid smelling of amyl and of cyanhydric acid. Its vapor impresses the tongue with an insupportable bitterness and causes, like cyanhydric acid, a sense of suffocation in the throat. It boils at 137° C., which is 8° lower than its isomer capronitrile. The cyanid of amyl is but slightly attacked by alkalies but acids transform it into formic acid and amylamine. Transient intermediate products are formed in this reaction.

Anhydrous phosphoric acid, as is well known, readily converts the salts of ammonium with the fatty acids into the corresponding

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nitriles. It was therefore natural to suppose that the cyanids might be formed by a similar reaction, so that, for example, formate of amylamine would yield cyanid of amyl. Dr. Hofmann found however that the action of phosphoric acid was in these cases more profound and did not yield the results expected. On the other hand the author calls attention to the fact that in the preparation of the nitriles by the action of sulphomethylate, &c., of potassium upon cyanid of potassium, the raw nitrile obtained possesses a most offensive odor, while the nitriles obtained by the action of phosphoric acid upon salts of ammonia have a very agreeable aromatic smell. On repeating the older experiments of E. Meyer upon the action of organic iodids upon cyanid of silver, Dr. Hofmann found that in this also the cyanids are formed in considerable quantities. The reaction succeeds best with the iodid of amyl, but much amylene and cyanhydric acid are formed at the same time. The author hopes to obtain the dicyanid of ethylene, $C_4H_4N_2$, isomeric with Simpson's cyanid, by the action of chloroform upon ethylene-diamin, or by treating cyanid of silver with iodid of ethylene. He considers it as probable that there exists a corresponding isomeric series of sulpho-cyanids.—*Comptes Rendus*, I, lxv, 335, 389, 448. W. G.

2. *On the same subject.*—Dr. Hofmann's communications on subject of the isomeric cyanids have called out a reclamation of priority on the part of M. Gautier, whose results agree with those of Dr. Hofmann as regards the action of the organic iodids upon cyanid of silver.—*Comptes Rendus*, lxv, 468. W. G.

3. *On certain hydrocarbons contained in coal-tar.*—BERTHELOT has discovered in coal-tar various hydrocarbons which had not hitherto been observed in that liquid as well as several wholly new substances of great interest. Of the former class the author mentions styrolene, $C_{16}H_8$, first in order, as one of the bodies obtained by the transformation of acetylene. The existence of cymene, $C_{20}H_{14}$, in coal-tar has been observed by several chemists, the liquid boiling at 166° C., proving to be cumolene, $C_{18}H_{12}$. Cymene boils at about 180° C., and exhibits the ordinary reactions of the benzol series. When heated to 280° C., with 80 parts of a saturated solution of iodhydric acid, cymene yields hydruret of decylene, $C_{20}H_{22}$, which boils between 155° and 160° C. The author has also found in coal-tar two hydrurets of naphtaline, $C_{20}H_{10}$, and $C_{20}H_{12}$; a hydruret of acenaphtene, $C_{24}H_{12}$, which is a liquid boiling at 260°, and a hydruret of anthracene which is also liquid and boils at 285° C. Fluorene is the name given by the author to a new hydro-carbon which separates in the distillation of the heavy oils. It is a white crystalline substance which exhibits a magnificent violet fluorescence and possesses a sweetish and irritating odor. It fuses at 113° and melts at 305°, and is very soluble in boiling alcohol. The solution of this body in sulphuric acid is colorless, but the least trace of nitrous acid colors it green, and more nitrous acid gives a violet color. Fluorene gives a red crystalline compound with picric acid.—*Comptes Rendus*, lxv, 465. W. G.

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II. MINERALOGY AND GEOLOGY.

1. *Note on the genus Palæacis* Haime, 1860 = (*Sphenopoterium* M. & W., 1866); by F. B. MEEK.—At the time the name *Sphenopoterium* was proposed for this genus by Meek and Worthen, the volume of the *Histoire Naturelle des Coralliaires*, in which the lamented Haime had a short time previously described it under the name, *Palæacis*, had not reached this country; nor was it until very recently received at any of the libraries at Washington, where we were then investigating the Illinois fossils. Owing to the fact that for a long time previous to the publication of the Illinois Report, our investigations were pursued in the west, where we were to a great extent cut off from foreign periodical scientific publications, we were also not aware of the fact, until after the printing of the Illinois Report, that von Seebach had called attention in *Zeitschr. der Deutsch. geol. Gesellsch.*, xviii, to the identity of *Palæacis* and *Sphenopoterium*:—otherwise we would have cheerfully adopted the name *Palæacis*, which has priority of date, and must take precedence.*

In first publishing a notice of this genus in 1860, we regarded it as a Coral, as Haime had also done. Milne Edwards, however, in publishing Haime's name and description, expressed some doubts, it appears, whether it is a coral, but left it provisionally where Haime had placed it, in the "*Zoantharia perforata*," or perforated section of Corals.

Being in considerable doubt in relation to the affinities of this genus at the time we were preparing the descriptions for the Illinois Report, and not being where we could have access to all the works on analogous fossils, we sent specimens of our species, *P. obtusa*, to Prof. Verrill, who has made an especial study of the corals, with the request that he should give us some suggestions in regard to the relations of the genus. After as careful an examination as could be made without preparing sections for the microscope, Prof. Verrill informed us that he was inclined to regard it as a Sponge, and not a Coral, which view was adopted by us, on his authority, in the Illinois Report.

Feeling a desire to settle more definitely, if possible, the question in relation to the affinities of this group, I recently prepared a section, as thin as the condition of the fossil would permit, of *P. obtusa*, and sent it to Prof. Verrill, who writes as follows:—

"The section of *Palæacis obtusa* sent to me is not sufficiently thin and transparent to be used with the higher powers, but I have made a somewhat careful examination of its structure as shown under powers below a quarter inch. The internal structure, like the external character, is entirely unlike any known coral, living or fossil, but agrees very well with several forms of fossil sponges. The section has been made vertically across the shorter diameter, through two of the cups. There is a central, imperfectly bounded

* Von Seebach is in error, however, in saying our description was published in 1861, as it was issued in 1860, but after Haime's, if I am not mistaken.

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area beneath the cups, which is traversed by numerous irregular, crooked, sometimes branching canals, which also pass in all directions through the surrounding tissue, but in less numbers; outside of the central area there are seen radiating darker and lighter lines, which appear like minute canals. They are often branched and quite irregular. When highly magnified the whole mass seems composed of a fine spongy tissue, which varies in density between the minute canals, thus giving rise to the darker and lighter lines. There is no appearance of vesicles, or anything like septa or plates, either vertical or horizontal, or walls of any kind around the cells. The only resemblance to corals seems to be in the external form, and radiating striæ of the cells, which, however, are not true septa, and are quite irregular like the striæ in the cups of many fossil and living sponges."

It may not be out of place in this connection, to state that I have scarcely any doubts, after examining a good series of specimens, that the two species, *Palæacis umbonata* and *P. cymbia*, proposed by von Seebach, are mere varieties of *P. obtusa* M. & W., which varies greatly in the characters upon which he has proposed to separate these two forms.

III. BOTANY AND ZOOLOGY.

1. *Monographia Salicum, auctore* N. J. ANDERSSON.—Part I. of this Monograph of Willows, which was communicated to the Royal Swedish Academy of Sciences at Stockholm, in October, 1863, is now published, in vol. 6, of its Transactions, and separately issued, in 4to, pp. 180, with 9 plates, crowded with figures of the details of about one hundred species. We have here about three-fourths of the systematic part, in advance of the elaboration in DeCandolle's Prodromus, which is, by this time, also printed off. The second part will contain the rest of the species, the *generalia*, &c.

The system of arrangement is simple; the primary groups, or tribes, are only three, and founded on the stamens. They are: the *Pleiandræ*, with 3 to many stamens, divided into the *Tropicæ* and the *Temperatæ*, and these, each into three or four ultimate sections; *Diandræ*, with two distinct stamens, much the largest group, divided into the *Microstylæ*, of four sections, the *Podostylæ*, of ten, and the *Macrostylæ*, of four; and finally the *Synandræ*, with two sections. These names indicate clearly the characters of the groups. The present part ends with the *Podostylæ*, and with species 105. As respects the European Willows, Dr. Andersson agrees with Wimmer, (whose elegant treatise was recently noticed in this Journal,) and accordingly regards many admitted species as of hybrid origin; but he unfortunately permits several, recognized as hybrids, to retain the rank of species. Under the principal types, a series of what may be termed sub-species, are coördinated. When the concluding part of this most important and faithful monograph comes to hand, we may hope to prepare a full abstract of the work, as far as relates to North American species, east of the Rocky Mountains. Perhaps it is not too late to suggest to the author a

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revocation of the name of the 92d species, *S. Novæ-anglicæ*, under which the author has combined two sub-species and several varieties, no one of which is recorded as inhabiting our New England States, or any district nearer than Saskatchawan and the Rocky Mountains. A. G.

2. *Flora Brasiliensis of* MARTIUS.—The 42d and 43d fascicles of this great work, were issued in April last. One includes the *Rosaceæ*, by Dr. J. D. Hooker, with 22 plates, done in Germany. Of the *Rosaceæ*, truly indigenous to Brazil, a little over 100 in number, 95 (under 7 genera) are of the suborder *Chrysobalanæ*. The other fasciculus is devoted to the *Combretaceæ*, by Dr. Eichler, about 65 species, under 9 genera, two of them established by Dr. Eichler, in his revision of the order, and illustrated by 15 plates. A. G.

3. *Lois de la Nomenclature, redigées et commentées* par M. ALPH. DECANDOLLE. Paris: Masson, 1867, pp. 60, 8vo.—This important pamphlet was printed, in August last, upon the request of a Committee of the Botanical Society of France, raised for organizing an International Botanical Congress, which, accordingly, was held in Paris at the close of the summer. The propositions, systematically drawn up and ably expounded by M. DeCandolle, have since been approved by this Congress, with some slight modifications, and recommended by it for general adoption. They seem to us to be, in almost all respects, judicious and timely. Upon receiving the report of the proceedings of this Congress, we may call attention to this revised code, or present to our readers a full abstract of it.

A. G.

4. Those features of the botany of Japan and adjacent regions, which are of the highest interest to us, have recently been considered by Miquel in a pamphlet, entitled—

Sur les Affinités de la Flora du Japan avec celles de l'Asie et de l'Amerique du Nord, (extr. des Archives Néerlandaises, ii, 1867.)—The first special notice of the now familiarly known relationship of Japan with Eastern United States botany, was probably given in this Journal, many years ago, in a review of the earlier parts of Siebold and Zuccarini's Flora Japonica. Of the article in the Memoirs of the American Academy, vol. 6, in which the subject is treated in detail, Prof. Miquel is hardly correct in stating, that it was written under the influence of the Darwinian hypothesis. Mr. Darwin's famous volume, if published, had not reached this country when this paper was read, although its leading idea was known here. All that is allowed in the memoir is, the probability "that what are termed closely related species may, in many cases, be lineal descendants from a pristine stock, just as domesticated races are;"—a proposition which, perhaps, very few naturalists would now contest.

It is by some oversight that Prof. Miquel credits only a single *Hydrangea* to North America, restricts *Malvastrum* to Eastern North America, while it is wanting east of the Mississippi, and abounds west of the Rocky Mountains, and deprives the eastern side of *Prosartes*. So far as we know, it is a mistake to credit *Symplo-*

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carpus (*Lysichiton* being separated) to the western, as well as the eastern side; and *Cymopterus*, in the same table (p. 16), must be replaced by *Phellopterus* or *Glehnia*, whichever may secure the right of priority. It is very interesting to note that there is, in Japan, a true *Symplocarpus*, if not *S. fœtidus* itself; and even more so, that *Croomia pauciflora*, sole representative of the group in our Southern Atlantic States, has been identified in Japan. The general theoretical views in explanation of these facts of distribution, as given in the matter referred to, are repeated, and more or less reinforced, at the close of Prof. Miquel's interesting *brochure*.

A. G.

5. *Tall Trees in Australia.*—It would appear that the famous "mammoth trees" of California are not only rivalled, but surpassed in height, in Victoria Colony, Australia. The principal facts which warrant this conclusion, are collected by Dr. Ferdinand Müller, Director of the State Garden at Melbourne, in his interesting pamphlet, recently issued, upon "Australian Vegetation, considered especially in its bearings upon the occupation of the Territory, and with a view of unfolding its resources,"—from which the subjoined extracts are derived:—

"The marvellous height of some of the Australian, and especially Victorian trees, has become the subject of closer investigation, since of late, particularly through the miners' tracks, easier access has been afforded to the back-gullies of our mountain-system. Some astounding *data*, supported by *actual* measurements, are now on record. The highest tree previously known was a *Karri-Eucalyptus* (*Eucalyptus colossea*), measured by Mr. Pemberton Walcott, in one of the delightful glens of the Warren river of Western Australia, where it rises to approximately 400 feet high. Into the hollow trunk of this Karri, three riders, with additional packhorse, could enter and turn in it without dismounting. On the desire of the writer of these pages, Mr. D. Boyle measured a fallen tree of *Eucalyptus amygdalina*, in the deep recesses of Dandenong, and obtained for it the length of 420 feet, with proportions of width, indicated in a design of a monumental structure placed in the exhibition; while Mr. G. Klein took the measurement of a eucalyptus on the Black Spur, ten miles distant from Healsville, 480 feet high! Mr. E. B. Hayne obtained, at Dandenong, as measurements of height of a tree of *Eucalyptus amygdalina:* Length of stem from the base to the first branch, 295 feet; diameter of the stem at the first branch, 4 feet; length of stem from first branch to where its top portion was broken off, 90 feet; diameter of the stem where broken off, 3 feet; total length of stem up to place of fracture, 365 feet; girth of stem three feet from the surface, 41 feet. A still thicker tree measured, three feet from the base, 53 feet in circumference. Mr. George W. Robinson ascertained, in the back-ranges of Berwick, the circumference of a tree of *Eucalyptus amygdalina* to be 81 feet at a distance of four feet from the ground, and supposes this eucalypt, towards the sources of the Yarra and Latrobe rivers, to attain a height of half a thou-

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sand feet. The same gentleman found *Fagus Cunninghami* to gain a height of 200 feet, and a circumference of 23 feet.

"It is not at all likely that, in these isolated inquiries, chance has led to the really highest trees, which the most secluded and the least accessible spots may still conceal. It seems, however, almost beyond dispute, that the trees of Australia rival in length, though evidently not in thickness, even the renowned forest-giants of California, *Sequoia Wellingtonia*, the highest of which, as far as the writer is aware, rise, in their favorite haunts at the Sierra Nevada, to about 450 feet. Still, one of the mammoth-trees measured, it is said, at an estimated height of 300 feet, 18 feet in diameter! Thus to Victorian trees, for elevation, the palm must, apparently, be conceded. A standard of comparison we possess in the spire of the Münster of Strasburg, the highest of any cathedral of the globe, which sends its lofty pinnacle to the height of 466 feet, or in the great pyramid of Cheops, 480 feet high, which, if raised in our ranges, would be overshadowed, probably, by Eucalyptus trees.

The enormous height attained by not isolated, but vast masses of our timber-trees, in the rich diluvial deposits of sheltered depressions within Victorian ranges, finds its principal explanation, perhaps, in the circumstance, that the richness of the soil is combined with a humid geniality of the climate, never sinking to the colder temperature of Tasmania, nor rising to a warmth less favorable to the strong development of these trees in New South Wales, nor ever reduced to that comparative dryness of air which, even to some entent in the mountain-ravines of South Australia, is experienced. The absence of living gigantic forms of animal life amidst these, the hugest forms of the vegetable world, is all the more striking.

Statistics of actual measurement of trees, compiled in various parts of the globe, would be replete with deep interest, not merely to science, but disclose, also, in copious instances, magnitudes of resources but little understood up to the present day. Not merely, however, in their stupendous altitude, but also in their celerity of growth, we have, in all probability, to accede to Australian trees the prize. Extensive comparisons, instituted in the Botanic Gardens of this metropolis, prove several species of Eucalyptus, more particularly *Eucalyptus globulus*, and *Eucalyptus obliqua*, as well as certain Acacias—for instance, *Acacia decurrens*, or *Acacia mollissima*—far excelling, in their ratio of development, any extra-Australian trees, even on dry and exposed spots, such into which spontaneously our blue gum-trees would not penetrate. This marvelous quickness of growth, combined with a perfect fitness to resist drought, has rendered many of our trees famed abroad, especially so in countries where the supply of fuel or of hardwoods is not readily attainable, or where for raising shelter, like around the cinchona-plantations of India, the early and copious command of tall vegetation is of imperative importance. To us here this ought to be a subject of manifold significance. I scarcely need refer to the fact, that for numerous unemployed persons, the gathering of Eucalyp-

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tus seeds, of which a pound weight suffices to raise many thousand trees, might be a source of lucrative and extensive employment; but on this I wish to dwell, that in Australian vegetation we probably possess the means of obliterating the rainless zones of the globe, to spread at last woods over our deserts, and thereby to mitigate the distressing drought, and to annihilate, perhaps, even that occasionally excessive dry heat evolved by the sun's rays from the naked ground throughout extensive regions of the interior, and wafted with the current of air to the east and south, miseries from which the prevalence of sea-breezes renders the more littoral tracts of West and North Australia, almost free. But in the economy of nature the trees, beyond affording shade and shelter, and retaining humidity to the soil, serve other great purposes. Trees, ever active in sending their roots to the depth, draw unceasingly from below the surface-strata, those mineral elements of vegetable nutrition on which the life of plants absolutely depends, and which, with every dropping leaf, is left as a storage of aliment for the subsequent vegetation. How much lasting good could not be effected, then, by mere scattering of seeds of our drought-resisting acacias and eucalypts and casuarinas, at the termination of the hot season, along any watercourse, or even along the crevices of rocks, or over bare sands or hard clays, after refreshing showers? Even the rugged escarpments of the desolate ranges of Tunis, Algiers, and Morocco, might become wooded: even the Sahara itself, if it could not be conquered and rendered habitable, might have the extent of its oases vastly augmented; fertility might be secured again to the Holy Land, and rain to the Asiatic plateau, or the desert of Atacama, or timber and fuel be furnished to Natal and La Plata. An experiment, instituted on a bare ridge near our metropolis, demonstrates what may be done."

A systematic catalogue of the known trees of Australia, with indications of their territorial distribution, occupies 18 pages of this essay; from which it appears, that in Australia, no less than 950 woody plants attain a height of at least 30 feet, or thereabouts.

A. G.

6. *Report on the disastrous effects of the destruction of Forest Trees now going on so rapidly in Wisconsin;* by I. A. LAPHAM, J. G. KNAPP, and H. CROCKER, Commissioners [appointed by the Legislature of the State]. Madison, Wisconsin, 1867, pp. 104, 8vo. —The topic so properly discussed by Dr. Mühler for Australia (in the above extract), is brought home to our attention in this essay, which we trust will be widely read and seriously considered. The essay has reached our hands too late for the preparation of an abstract, and for specially noting many interesting points in matters of climatology or vegetable physiology, some few of which might be more or less criticised. But the Report as a whole strikes us as sound and able, as well as timely. A.G.

7. *Annales Musei Botanici Lugduni Batavi* edidit F. A. G. MIQUEL. Tom. I–III, fasc. 4. 1863–1867, fol.—Since our announcement of this work, and analysis of the contents of the earliest fas-

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ciculi, in 1864, it has been so indefatigably prosecuted by Prof. Miquel, that two large volumes have been completed, and the third is well under way. A large portion is naturally devoted to Japanese botany, in the 2d and 3d volumes, under the separate heading of *Prolusio Floræ Japonicæ;* and these prolusions are also separately published. When finished, as they are likely soon to be, they will form a nearly complete exposition of Japan botany, as far as is exemplified in the rich and long-accumulated stores of the Leyden herbarium. The various and interesting contents of these volumes invite attention and remark on every side, but are already much too extensive to be compassed here. They comprise considerable monographs, or detailed articles, by collaborators, such as Mettenius, Schott, Hasskarl, DeVriese, &c., who have already passed off the stage, as well as by Sande Lacoste, Oudemans, and others, who are still active; but the greater part of the Japanese Botany is Prof. Miquel's own work. In the second volume is an interesting article on *Nymphæaceæ*, by Caspary, with new sections of *Nymphæa*, and an exhaustive analysis of oriental species, a new discrimination of *N. alba* from *N. odorata*, and considerable details upon the variations of the latter, commending them, moreover, to the scrutiny of North American botanists upon the live plants. Of *Nuphar*, he admits three 5-sepalled species; *N. Japonicum* (which he fully describes and figures, both yellow and reddish forms), *luteum*, and *pumilum* (*Kalmianum*).

In characterizing his two primary sections of *Nymphæa*, Dr. Caspary proposes to restrict the botanical term "*connata*," to the case of the junction of organs which were at first separate, and to use the term "*conjunctim enata*," for the ordinary case of primordial union. It were certainly desirable, for clearness, to express the two things by different, rather than identical language; but Caspary's appropriation of the term *connate*, is open to the three objections,—1st, that it is thus divorced from the sense which it generally bears in descriptive botany, and also, 2d, which befits its literal meaning (*born with* the union), while, 3d, it does not etymologically answer well to the use he puts it to. If really needful to restrict any word to designate the comparatively rare case of post-genital union, *coalita* would be the fitter one, and would involve less change of recognized botanical language.

The depressed umbelliferous plant, published by the present writer in Cooper and Suckley's botanical report of Stevens' Pacific Railroad Exploration as *Cymopterus? littoralis*, and referred to in the account of C. Wright's Japan collection (since then collected in Japan by Maximowicz, &c.) has now two genuine names, of which the relative priority is yet uncertain. In Bentham and Hooker's Genera Plantarum, p. 905, which is by this time published in England, it is described as the genus *Phellopterus;* in Maximowicz's admirable collections it is distributed, and in Miquel's Annales, 3, p. 61 (1867), it is enumerated, but not characterized, as *Glehnia littoralis*, F. Schmidt, Fl. Sanchal, ined."

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7. *Synopsis of the species of Starfishes, in the British Museum, with figures of some of the new species;* by JOHN EDWARD GRAY, Ph.D., 67 pages, quarto, with 16 plates, London, John Van Voorst. This work includes descriptions of the numerous new genera and species described by Dr. Gray in the Annals and magazine of Natural History, 1840, and the Proceedings of the Zoölogical Society of London, 1847, the plates, which were prepared for a more extended work at the time of the original publication of the species and have since been laid aside, are very accurate and beautifully executed, representing, in most cases, species not before figured. The descriptions are reproduced from the original papers with the addition of some synonyms, and lists of addittional species. It is greatly to be regretted that the loss of the types of many of the new species, especially those from the west coast of America, collected by H. Cuming, Esq., prevents their being figured or more fully described. This work, however, will be extremely valuable to all investigators of this interesting group of animals on account of the many excellent figures of rare and remarkable species. V.

IV. ASTRONOMY.

1. *Discovery of new planet* (93).—Prof. WATSON discovered a new planet on the night of the 24th of August. It resembles a star of the 11th magnitude. The following are some of the earlier and later observations, provisionally reduced.

Ann Arbor M. T.				(93)α			(93)δ		
1867, Aug. 24,	15h	13m	22s·1	0h	6m	48s·40			
24,	16	5	52·0	0	6	46·86	−3°	11′	48·″3
25,	10	2	42·9	0	6	17·04	3	13	7·7
25,	10	17	51·1	0	6	16·80	3	13	7·3
26,	10	47	51·4	0	5	36·35	4	42	55·3
Oct. 15,	9	48	5	23	24	30·35	4	42	25·3
16,	9	48	32	23	23	58·00	−4	42	20·5

2. *Discovery of new planet* (94).—Prof. WATSON discovered another new planet, also resembling a star of the 11th magnitude, on the night of the 6th of September. The following are the earlier and later observations.

Ann Arbor M. T.				(94)α			(94)δ		
1867, Sept. 6,	14h	48m	10s·1	0h	56m	33s·46			
6,	16	15	37·4	0	56	31·34	+6°	11′	14″·5
7,	10	12	21·4	0	56	6·99	6	10	42·2
8,	9	59	29·2	0	55	33·40	6	0	54·7
Oct. 15,	11	35	6	0	27	23·20	4	55	28·9
16,	10	30	4	0	26	40·34	+4	53	19·6

3. *Shooting Stars in August*, 1867.—At New Haven it was cloudy on the nights of 9–10th and 10–11th of August.

(1.) *At Philadelphia.*—The following is the result of the watch on the morning of the 10th, by Mr. B. V. Marsh, and Mr. C. H. Darlington, each watching independently of the other, and directing their attention mainly toward Perseus.

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Time.	*B. V. Marsh.* conf.	*B. V. Marsh.* non-conf.	*C. H. Darlington.* conf.	*C. H. Darlington.* non-conf.
$1^h\ 3^m$ to $1^h\ 45^m$	10	7	10	4
1 45 " 2 0	6	4	6	1
2 0 " 2 15	3	0	3	1
2 15 " 2 30	3	2	1	1
In $1^h\ 27^m$	22	13	20	7

Seven of those seen by Mr. Marsh, and six seen by Mr. Darlington were estimated to have been bright enough to be visible in moonlight. The meteors originating near the radiant indicated the usual position, while some of the more distant seemed to proceed from Cassiopeia. Several had trains but they were not persistent nor were they very bright. The next night the sky was overcast.

(2.) *At Marathon, N. Y.*—Mr. Lewis Swift saw none during an hour's watching between 9^h and 10^h P. M., Aug. 9th. Resuming observation in the morning he saw (watching alone) in $1^h\ 10^m$, beginning at a quarter past two o'clock, 39 meteors. Thirty-four were conformable to a radiant in Perseus. Three larger than any of the 34 had a radiant in R. A. $3^h\ 30^m$, Dec. $+27°$. The paths were generally short. One not more than $\frac{1}{3}$ of the moon's diameter in length was 1° from γ Persei. Fog prevented further observations.

The evening of the 10th was cloudy. At 3 o'clock on the morning of the 11th, 17 were counted in 30 minutes, when the fog again interfered. The radiant point for 15 of them was thought to be slightly removed from its place on the previous morning.

Aug. 12th,	in 15^m	from 2^h A. M.,	7 were seen,	all conf.
" "	60^m	" $9\frac{1}{2}^h$ P. M.,	3 " "	2 conf.
" 13th,	30^m	" 1^h A. M.,	2 " "	both "

Mr. Swift paid special attention to the number of meteors visible, and to the location of the radiant. The latter he places on the

10th (A. M.),	in R. A.	$2^h\ 50^m$,	N. P. D. 37°.
11th "	"	$2^h\ 55^m$,	" 38°.
12th and 13th "	"		doubtful.

The diameter of the circle of radiation was estimated at from 6° to 8°.

(3.) *At Winchendon, Mass.*—Mr. F. W. Russell reports in the early part of August, 6 or 7 meteors per hour, all radiating from near Aquila. The first specific August meteor was seen about the 5th, and the radiant during the next few days was in Cassiopeia. It gradually passed down into Perseus.

Aug. 7th. From $9^h\ 45^m$ to $10^h\ 45^m$ P. M., 8 meteors, all from radiant near ϵ and δ Cassiopeia.

Aug. 9th. From $12^h\ 15^m$ to $12^h\ 55^m$ A. M., 7 conf., 10 non-conf.
Aug. 9th. Evening. A few large meteors from η Persei.

Aug. 11th.	From 2^h	to 3^h A. M.,	28 conf.,	0 non-conf.
" "	" 3^h	to $3^h\ 40^m$ "	15 "	1 "

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Those marked conformable all diverged from an area 25° in diameter whose center was R. A. 44°, N. P. D. 31°. Thirty-three were from an area 5° in diameter, whose center was R. A. 47° 45′, N. P. D. 31°.

Aug. 12th.	From 2^h to 3^h (hazy)	18 conf.	2 non-conf.
" "	" 3^h to 3^h 30^m (clear)	23 "	2 "

About ⅔ths of the paths produced backward, crossed a circle 16° in diameter, whose center was in R. A. 50°, N. P. D. 33°. This was considered to be as nearly as could be determined the center of the area of emanation. Mr. Russell adds: "It was emphatically evident that the position of the radiant on the 11th, was not that of the 12th. The area had moved toward μ Persei, and a little toward α also. Moreover the area seemed elliptical, the major axis being in declination and with a ratio to the minor axis of 5 : 2."

Mr. Russell watched alone and was interrupted frequently by the clouds and fogs.

(4.) *At Florence.*—Prof. Donati reports (Bulletitno Meteor., Sept. 1867) the following results of observations made at Florence this year.

1867. Aug.	No. of observers.	Number of shooting stars seen. 9^h–10^h	10^h–11^h	11^h–12^h	12^h–1^h	1^h–2^h	2^h–3^h	3^h–4^h	Total.
9–10	3	6	35	25	29	51	61	30	237
10–11	4	32	48	39	50	122	160	106	557
11–12	3	27	27	30	34	53	94	86	351
12–13	2	6	24	12	14	18	28	28	130
13–14	1	3	6	6	6	9	7	10	47

Of these 1322 meteors, 972 were recorded as conformable and 350 unconformable. The maximum deduced from this table was from two to three o'clock on the morning of the 11th of August.

H. A. N.

4. *Meteoric Astronomy.* A treatise on Shooting Stars, Fireballs and Aerolites; by Prof. Daniel Kirkwood. 12mo, pp. 130, Philadelphia, J. B. Lippincott & Co. 1867.—This little treatise gives in a popular form a summary of the more important astronomical relations of the igneous meteors. In addition the author discusses the relations to the nebular hypothesis of the knowledge recently acquired respecting them. The work constitutes a valuable and interesting contribution to our literature upon this subject.

Some inadvertencies ought, however, to be corrected in any future edition. For example, he ascribes (p. 27) the change of the epoch of the August meteors from the 25–28th of July in the 9th century to the 9–11th of August in the 19th, to a motion of the nodes of their orbits along the ecliptic. The amount of motion is, however, hardly perceivable, when allowance is made for the precession of the equinoxes, and for the change of the calendar. In his list of April showers some dates are improperly included and others improperly omitted. Again, in the accounts of the April, August and December meteors, more credit, we think, should have been given to Mr. Herrick's investigations. This oversight is prob-

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ably due to the fact that the author did not attempt to write the history of the subject. But the frequent references to other laborers in this field of science make the omission noticeable. H. A. N.

5. *On Meteors in the Southern hemisphere;* by Dr. E. HEIS and Dr. GEORGE NEUMAYER. Mannheim, 1867, 24 pp. 4to, (reprinted from Dr. Neumayer's "Discussion of Met. and Magn. Obs. made at the Flagstaff Observatory.")—This memoir is very important as giving almost the only observations we have of meteors observed in the southern hemisphere. The paths of 2088 meteors seen between March, 1858, and October, 1863, at the Flagstaff Observatory, at Melbourne, are discussed by Dr. Heis. One of the most noticeable results is the lack of unusual numbers of meteors on the 10–12th of August. This was to have been expected as the radiant in Perseus is below the horizon at Melborne.

6. *Sternschnuppen und Kometen,* (Extr. from "Kalender für alle Stände") by Carl von Littrow. Vienna, 1867, pp. 42, 8vo.—This is a history and summary of the recent investigations which have led to the important discovery of the intimate relation between shooting stars and comets.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Ascent of Mt. Hood, in Oregon, and determination of its height.*—Lieut. Col. Williamson, U. S. Engineers, has just communicated to the California Academy of Natural Sciences an account of his successful attempt to fix the height of this famous and much controverted mountain. We extract the essential part of it, as follows:

"The stations used were Astoria, Fort Vancouver, Fort Dalles, camp on slope of Mount Hood, and summit of Mount Hood. Observations had been taken for several years at Astoria for me by Louis Wilson, United States Tidal Observer, at 7 A. M., 2 P. M., and 9 P. M., of every day, besides hourly observations for ten days or more of each month. The cistern of this barometer is 53 feet above mean low tide.

"At Fort Vancouver, observations of the same character were commenced July 1st of this year, and are still going on. At Fort Dalles similar observations have been made since July 10th. The observations at the camp on the mountain slope were commenced at 7 P. M., on August 22d, and continued hourly (with few omissions) until 8 A. M., on the 24th. The barometer at the summit was hung up at 1.30 P. M., August 23d, and allowed to stand a half hour in free air, but protected from the direct rays of the sun. It was there adjusted and observed at 2 P. M., 2:15 P. M., and 2:30 P. M., by Mr. Heuer and Mr. Best independently, and the two records as shown to me were essentially the same. The mean reading of the barometer reduced to 32° Fah. was 19·941 inches, with an observed air temperature of 41·7 and wet bulb of 31·3.

"The height of Fort Vancouver above Astoria was computed from the mean of the simultaneous observations taken during the

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months of July and August. The height of the Dalles above Fort Vancouver was deduced from the corresponding observations during twenty-one days in July, together with those for the month of August. The height of the camp on the mountain slope above Fort Vancouver, and also the height of that camp above Fort Dalles, were then separately computed from the daily means of the observations taken at the three stations during August 23d. The difference between the two should give the same result as by the direct calculations between Fort Vancouver and Fort Dalles, but, on account of the short period observed on the mountain camp, a plus correction of a little over eight feet was found necessary to the estimated height of that camp to make the three results agree.

"It then remained only to calculate the height of the summit of Mount Hood above the mountain camp. The mean of the three observations of the barometer was assumed as the nearest approximation we can have to the mean pressure for that day, as the horary oscillation at the summit is unknown.

"With regard to the mean temperature for that day, we have no positive data to determine it. We cannot take the observed temperature, as the observations were taken during the hottest part of the day.

"By consulting the hourly observations of the thermometer at the camp, I find the range there is between 63° and 43·7°, or nearly 20°, and supposing nearly as great a range of temperature on the summit, I have assumed the mean temperature there, for that day, to be 34°.

"The following are the final results of the computations:

Stations.	Inter. alt.	Alt. above sea line.
Sea level at mean low tide		0
Astoria	53	53
Fort Vancouver	79	132
Camp on mountain slope	5,820	5,952
Summit of Mt. Hood	5,273	11,225

"The computations are made with new tables, which will shortly be published, and which give results similar to those by Plantamour's formula, based on Regnault's constants. They give the results somewhat higher than if Guyot's tables had been used, the latter giving the height of the summit at 11,185 feet."

The ascent was made on the twenty-third of last August, under very favorable circumstances of weather, and the instruments used (new ones, by James Green, of New York) were brought down in perfect order, and compared with the standard at Fort Vancouver.

With regard to the discordance between his result and that of a party which ascended the mountain a year earlier, and from the temperature, 180° F., at which they observed water to boil, deduced a height of 17,600 feet, Col. Williamson remarks:

"The reason is that the instruments used were unreliable, and this method of computing the altitude defective. With a boiling-point apparatus (or thermo-barometer, as it is called), even of the most approved kind, the results by boiling water are far inferior to those by the cistern-barometer; but if the observations are

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made by a common thermometer, with small places for degrees, as was the case in this instance, and the instrument not protected from drafts of air, the results are utterly unreliable, and, therefore, worse than worthless."

Prof. J. D. Whitney, State Geologist of California, who visited Oregon this summer, writes (in a private letter) concerning the same ascent: "The measurement of Mt. Hood published abroad by Prof. Alphonso Wood was in reality made by Rev. Mr. Atkinson, of Portland, who carried up his own thermometer (one of Kendall's, with a heavy metallic scale), made the observations, and calculated them by a rule which he found in Porter's Chemistry."

In our May number (vol. xliii, p. 416–9), we quoted from the Proceedings of the Royal Geographical Society a story told by a Rev. H. K. Hines of his own ascent of Mt. Hood, in July of last year, wherein that gentleman distinctly conveys the impression that he, too, had boiled water at 180° upon the summit, and calculated from it a height for the mountain of 17,640 feet, thus confirming Mr. Atkinson's result with a signal, not to say singular, closeness. Prof. Whitney says farther, with reference to this: "Mr. Hines never carried up any instruments at all, as I ascertained on the spot from those who went up with him. I had felt certain of this before, for the simple reason that he had given figures identical with those of Atkinson and Wood, which were evidently erroneous; as also because, in the account which he published in the newspapers on his return, he said never a word about having made any measurements, or having any instruments with him. It is, then, a clear case of piracy."*

Prof. Whitney himself made, during his brief visit, the best trigonometrical observations that circumstances permitted upon the heights of Hood, St. Helens, and Adams, and his results, as yet only rudely worked out, gave him over 12,000 feet for Hood, and about 1,000 feet less for the other two, which appear to be nearly of the same height. Mt. Rainier he was unable to observe, but thinks, judging by the eye alone, that it is the highest of all the mountains of Oregon and Washington Territory. Col. Williamson refers to these measurements as tending to confirm the accuracy of his own; and, while hoping that other parties, with good instruments, will repeat his observations, he yet expresses his confidence that the result he has reached will not be varied a hundred feet.

2. *American Association for the Advancement of Science.*—The sixteenth meeting of the American Association for the Advancement of Science was held at Burlington, Vt., in August last, commencing on Wednesday the 21st and closing on the Monday evening following. The officers of the meeting were Prof. J. S. Newberry, President, Prof. J. Lovering, Permanent Secretary, Prof. C. S. Lyman, General Secretary. The Vice President, Prof.

* Mr. Hines's claim is not put forward *quite* so categorically as it was represented in our reprint of this article. By an error of the press, his statement, "This was found to be 17,460 feet high, the thermometer standing at 180°," is printed "This *we* found," etc. On the difference between *was* and *we* he would possibly found a claim to save his character for veracity.

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W. Gibbs, and the Treasurer, Dr. A. L. Elwyn, were not present. Dr. B. A. Gould was elected chairman of Section A, Mathematics and Physics, and Prof. J. W. Dawson, of Section B, Natural History and Geology.

The whole number of papers read was 63—30 in Section A, and 33 in Section B. The papers, generally, would compare favorably in interest and importance with those of previous meetings.

The attendance of members was about the same as at Buffalo—some seventy-five or eighty. Though not as great, for various reasons, as before the war, it was yet larger than was generally anticipated, and abundantly indicative of the abiding interest felt in the Association by the scientific men of the country. The spirit of the meeting was excellent throughout, and the discussions often of the highest interest. A noticeable feature was the number of the younger men of science who took part, some of them for the first time, and the impression of high promise made by many of them in their several fields of effort. At the same time, the absence of many of the older men, so active in former meetings, could not but be generally remarked. Some had died—among them Prof. Bache; others, like Prof. Henry, were kept away by illness, or other causes.

The meeting was in all respects a successful one, and the Association may now be regarded as permanently re-established, with every prospect of as full an attendance of members, and as happy an influence on the science and the scientific men of the country in the future as at any former period. The success of the meeting was promoted in no small degree by the active coöperation of many of the citizens of Burlington, and the hospitalities and courtesies extended to the Association, both by individuals and corporations, contributed largely to the comfort and enjoyment of the members. The excursion on the Lake and to the Gorge of the Ausable, by invitation of the Champlain Transportation Company, and that to Mount Mansfield by invitation of W. H. H. Bingham, Esq., deserve to be particularly mentioned.

In default of the customary address by the retiring president, (Dr. Barnard being in Europe) the address this year was given by the president, Prof. Newberry, on "Modern Scientific investigation—its Methods and Tendencies."

Among the general business transacted was the appointment of a commission, "To examine the Linnean rules of Zoological Nomenclature by the light of the suggestions and examples of recent writers, and to prepare a code of laws and recommendations in conformity with just modern usage, to be submitted to the Association at the next meeting." The commission, as appointed, consists of Profs. J. D. Dana, J. Wyman, S. F. Baird, J. Leidy, J. S. Newberry, J. W. Dawson, Wm. Stimpson, S. H. Scudder and F. W. Putnam.

Prof. John Torrey was appointed on the committee of Weights and Measures in place of the late Prof. Bache.

Dr. B. A. Gould was appointed to prepare an address on the Life and Services of Prof. Bache, to be delivered at the next meeting.

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The next meeting was appointed to be held in Chicago, commencing on Wednesday, the 5th of August, 1868.

The officers elected for that meeting, are Dr. B. A. Gould, President, Col. Charles Whittlesey, Vice President, Prof. J. Lovering, Permanent Secretary, Prof. A. P. Rockwell, General Secretary, Dr. A. L. Elwyn, Treasurer.

The following is a list of the papers read.

IN SECTION A.—MATHEMATICS AND PHYSICS.

1. On the optical method of studying Sound; Prof. J. Lovering.
2. New determination of the distance of the Sun; Prof. Simon Newcomb.
3. Apparatus for illustrating Wave Motion; Prof. C. S. Lyman.
4. On the Theories of Boussingault and Thenard of the difference between Stale and Freshened Bread; Prof. E. N. Horsford.
5. On the relative values of Gold and Silver for a series of years; E. B. Elliott.
6. Remarks on Meteorological results deduced from the new method of registration; Prof. G. W. Hough.
7. Remarks on the laws of winds, with some account of progress in the investigation of the same; Prof. J. H. Coffin.
8. On the Periodicity of the Aurora; Prof. J. Lovering.
9. Occupations of the population classified; E. B. Elliott.
10. On the determination of latitude from observations in the prime vertical; Prof. W. A. Rogers.
11. On new diagrams and derivative symbols, illustrating the prominent characteristics of the chemical elements; Prof. S. D. Tillman.
12. On the Velocity of transmission of signals by the Electromagnetic Telegraph; Dr. B. A. Gould.
13. On the Structure of Ice in its relations to the sudden disappearance of Ice on Lake Champlain; Prof. E. N. Horsford.
14. The Geodetic Triangulation of the Coast of New England, Prof. Bache, late Superintendent of the U. S. Coast Survey; Prof. J. E. Hilgard.
15. Preliminary notice of Experiments on Snow at temperatures below 32° Farenheit; Prof. E. Hungerford.
16. Remarks on Personal Equation in Transit Observations; Prof. G. W. Hough.
17. Tellurium a Metal; Dr. L. Bradley.
18. On a new method of Measuring Musical intervals upon a spiral projection; S. D. Tillman.
19. Suggestions on the Scientific and Practical Relations of Wood Spirit; Prof. J. Hyatt.
20. On certain Laws of Production and Trade; E. B. Elliott.
21. On the Conversion of Iron into Steel by means of carburetted Hydrogen Gas; Prof. Jas. Hyatt.
22. On the Knowledge of the Satellites of Jupiter before the time of Galileo; Prof. Jas. Hyatt.
23. On the Effects of Sunshine on Fires; Prof. E. N. Horsford.
24. On the Communications of Vibrations; Prof. B. Peirce, read by Prof. Lovering.

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25. Indian Architecture; L. H. Morgan.
26. Notes on the Duke of Argyle's theory of the flight of Birds, with illustrations derived from the Trochilidae; L. E. Chittenden.
27. On the use of Months for Dates; J. F. Holton.
28. On Elliptic Integrals by Series; David Trowbridge, presented by Dr. B. A. Gould.
29. On Euler's Universal Formulæ for the Summation of Series; David Trowbridge, presented by Dr. B. A. Gould.
30. On Observations of Venus near inferior conjunction; Prof. C. S. Lyman.

IN SECTION B.—NATURAL HISTORY, AND GEOLOGY.

1. The Distribution of Precious Metals in the United States; Col. Charles Whittlesey.
2. The Geological Relations of the Mastodon and Fossil Elephant of North America; Prof. James Hall.
3. Considerations drawn from the Study of the Orthoptera of North America; Samuel H. Scudder.
4. Traces of Ancient Glaciers in the White Mts.; G. L. Vose.
5. The Origin of the so-called Lignilites or Epsomites; Prof. O. C. Marsh.
6. The Geographical Distribution of the Sediments and the Fossils of the Hamilton, Portage, and Chemung groups of New York; Prof. James Hall.
7. The distribution of Limnæa megasoma and cognate genera; L. E. Chittenden.
8. Upon some remarkable Fossil Fishes obtained by Rev. H. Herzer, from the Devonian Rocks at Delaware, Ohio; Prof. J. S. Newberry.
9. The Fossil Insects of North America; S. H. Scudder.
10. The Winooski Marbles of Colchester, Vt.; Prof. C. H. Hitchcock.
11. The Zoological affinities of the Tabulate Corals; Prof. A. E. Verrill.
12. The Coal Measures of Illinois; Prof. A. H. Worthen.
13. New Points in the Geology of Nova Scotia and New Brunswick; Prof. J. W. Dawson.
14. On some New Fossil Sponges from the Lower Silurian: Prof. O. C. Marsh.
15. On the occurrance of Fossil Sponges in the successive groups of the Paleozoic Series; Prof. James Hall.
16. The American Beaver; Lewis H. Morgan.
17. The Distortion and Metamorphosis of Pebbles in Conglomerates; C. H. Hitchcock.
18. On some Fossil Reptiles and Fishes from the Carboniferous Strata of Ohio, Kentucky, and Illinois; Prof. J. S. Newberry.
19. Cotta's Law of the Earth's Development; R. W. Raymond.
20. On Mountain Masses of Iron Ore in the United States; Col. Charles Whittlesey.
21. On the Lower Silurian Brown Hematite Beds of America; B. S. Lyman.

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22. Explanations of the Geological Map of Maine; Prof. C. H. Hitchcock.
23. On the Geographical Distribution of Radiates on the West Coast of America; Prof. A. E. Verrill.
24. Considerations relating to the Climate of the Glacial Epoch in North America; Prof. Edward Hungerford.
25. Depression of the Sea during the Glacial Period; Col. Chas. Whittlesey.
26. Ripton Sea Beaches; Prof. Edward Hungerford.
27. On the Cretaceous and Tertiary Flora of North America; Prof. J. S. Newberry.
28. On certain Effects produced upon Fossils by Weathering; Prof. O. C. Marsh.
29. Geology of Vermont; Prof. C. H. Hitchcock.
30. The Insect Fauna of the summit of Mt. Washington as compared with that of Labrador; Dr. A. S. Packard, jr.
31. Remarks on the Ichthyological Fauna of Lake Champlain; F. W. Putnam.
32. The Embryology of Libellula (Diplax), with notes on the Morphology of Insects, and the classification of the Neuroptera; Dr. A. S. Packard, Jr.
33. On the Flowering of Plants; James Hyatt.

3. *National Academy of Sciences.*—At the recent August meeting of the National Academy of Sciences, held at Hartford, the following papers were presented.

1. The structural character of the Selachians; L. Agassiz.
2. Protest against modern nomenclature in Zoology; L. Agassiz.
3. On homocercy and heterocercy; L. Agassiz.
4. On the significance of classes in the Animal kingdom; L. Agassiz.
5. On sterility among Skates; L. Agassiz.
6. The fifth pair of nerves and the organ of hearing in Skates; L. Agassiz.
7. On periodical orvulation in Sharks and Skates; L. Agassiz.
8. The circulation of blood in Selachians; L. Agassiz.
9. Parasitic Crustacea in the gills of Sharks; L. Agassiz.
10. On the duration of the electric discharge; O. N. Rood.
11. On new processes in analytical chemistry; W. Gibbs.
12. On certain points in the theory of atomicities; W. Gibbs.
13. Spectroscopic notices; W. Gibbs.
14. On determination of wave lengths by the method of comparison; W. Gibbs.
15. Embryology and affinities of Cyclopterus; L. Agassiz.
16. Algebras; Benjamin Peirce.
17. The limitations and conditions of associated linear algebra; Benjamin Peirce.
18. Single, double and triple linear associative algebras; Benjamin Peirce.
19. Quadruple linear associative algebra; Benjamin Peirce.
20. The precision of the equinoxes and rotation as resulting from

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the theory of the gyroscope, with remarks explanatory of the deviation of rifled projectiles; G. Barnard.

21. Notes on a problem in curvature; T. Hill.

22. Observations in 1866 and 1867 of right ascensions of stars observed by d'Agelet in 1783–5; B. A. Gould.

23. Determinations of the proper motions of stars first observed by d'Agelet; B. A. Gould.

24. Remarks on the geological relations of the Mastodon and Fossil Elephant, suggested by the discovery of the Cohoes Mastodon; Jas. Hall.

25. On the value of certain groups in the geological series when studied in their geographical extension; Jas. Hall.

26. On a process of integration used in the case of a planet's orbit disturbed by small forces; Theodore Strong.

4. *Mineralogical Nomenclature.*—In my article on Mineralogical Nomenclature, page 146 of this volume, I observe that names after persons were not used by the ancients. I failed to allude to a case cited from Pliny (xxxvi, 67) by von Kobell, in his excellent *Geschichte der Mineralogie* (Munich, 1864)—that of *Obsidian*, or more correctly *Obsian*, named after Obsius, who Pliny says discovered the substance in Ethiopia,—an example referred to in 1790 by Werner in a defense of his own use of such names (Bergm. J., i, 103, 1790). But this is not strictly an example of a personal name of the kind intended. For Pliny uses *Obsian* not as a substantive but as an adjective; the mineral was not *Obsian* but *Obsian glass* or *Obsian stone; vitrum obsianum*, *lapis obsianus*, and *obsiana* [vitra], occurring in the course of the paragraph. The addition of the termination *ite* to Obsian would, according to mineralogical method, make a name equivalent to Pliny's *lapis obsianus.* Names of persons ending in *an* (as Octavian, Tertullian) were common among the Romans; and this is so far reason for avoiding the termination in names of stones.

Some critics question the existence of the reputed Obsius, and reject Pliny's explanation. J. D. DANA.

5. *British Association.*—The British Association was in session at Dundee in September last, commencing its session on Wednesday the 4th. The names of over 2000 attendants on the meeting were enrolled, of whom more than 700 were ladies. The President of the year, the Duke of Buccleuch, opened the meeting with a brief and popular address, much less labored and scientific than the Association has been accustomed to hear from its President. The receipts for the year past amounted to £787, and the expenditures to £777. We have not space at this time for a notice of the various papers presented.

6. *Walker Prizes of the Boston Society of Natural History.*—The subjects for the annual prizes of 1868 and 1869, are as follows: For 1868, Adduce and discuss the evidences of the coëxistence of man and extinct animals with the view of determining the limits of his antiquity. For 1869, On the range of Arctic and Alpine plants in North America, with an enumeration of the species. On the nature of the prizes, see vol. xl, p. 137, of this Journal.

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V. MISCELLANEOUS BIBLIOGRAPHY.

1. *The Mechanical Theory of Heat with its application to the Steam Engine, and to the physical properties of bodies;* by R. CLAUSIUS, Prof. of Physics in the University of Zurich, edited by Prof. T. Archer Hirst, F.R.S., with an introduction by Professor Tyndall. London, John Van Voorst, 1867. 8vo, pp. 376.—This volume consists of nine memoirs by Prof. Clausius which were originally published in Poggendorff's Annalen and elsewhere. In 1864 the author prepared for the press a collected edition of them, adding notes and appendices. The present volume is an English edition containing, however, an additional memoir (the 9th) which has appeared since 1864. The 5th memoir was reprinted in this Journal, (II, xxii and xxiii) from the Philosophical Magazine.

The following are the titles to the memoirs. Introduction; On the treatment of differential equations which are not directly integrable. 1st memoir, On the moving force of heat, and the laws of heat which may be deduced therefrom. 2d, On the deportment of vapor during its expansion under different circumstances. 3d, On the theoretic connexion of two empirical laws relating to the tension and the latent heat of different vapors. 4th, On a modified form of the second fundamental theorem in the mechanical theory of heat. 5th, On the application of the mechanical theory of heat to the steam engine. 6th. On the application of the theorem of the equivalence of transformations to interior work. 7th, On an axiom in the mechanical theory of heat. 8th, On the concentration of rays of heat and light, and on the limits of its action. 9th, On several convenient forms of the fundamental equations of the mechanical theory of heat.

2. *Condition and doings of the Boston Society of Natural History.* Boston, 1867.—In this report are included the reports of the Custodian, the Librarian, the curators of the various special departments, and the Treasurer, together with obituary notices of two prominent and active members of the society, Dr. A. A. Gould and Dr. Henry Bryant. The reports show continued enterprise and activity in all departments of the society, and a highly encouraging financial condition. During the year two important bequests have been received, one of $20,090 from P. P. Pope, Esq., and $10,000, with a valuable collection of shells from Miss S. P. Pratt. Important improvements have been made in the building, for the better accommodation of the rapidly increasing library and collections. The publication of both the Memoirs and Proceedings have gone forward with unusual rapidity, and a volume of the Correspondence and Entomological notes of Dr. T. W. Harris is announced as authorized to be published. During the year forty-four papers have been presented to the Society from thirty-one individuals.

3. *The Culture demanded by Modern Life.*—Under this title Messrs. Appleton & Co. have published a collection of addresses and arguments in favor of scientific training by Faraday, Tyndall, and a number of the most eminent English and American scientists

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of the present day. This excellent and useful compilation is due to Prof. E. L. Youmans whose labors in the cause of science are familiar to all and to whom we owe a collection of papers on the correlation of forces as well as original scientific works of great merit. Prof. Youmans has done good service to the cause of scientific education in our country by the preparation of this work. He has brought together a mass of argument from scattered and, to most readers, inaccessible sources. These papers treat the subject from about every point of view. They vary, as might be expected, in ability, but they are without exception readable and interesting. Mr. Youmans's own lecture on the scientific study of human nature is very valuable and suggestive and his introduction to the reader is well written and appropriate. The gem of the work is, in our opinion the noble and characteristic discourse of Faraday on the education of the judgment, and we are glad to see his words put into a permanent form. In conclusion we heartily thank Prof. Youmans for his work and commend it to the earnest attention of teachers. G.

4. *On the distribution of temperature in the lower region of the earth's atmosphere;* by Professor HENRY HENNESSY, F.R.S. (Ext. Roy. Irish Acad.) 4to, 58 pp.—Professor Hennessy discusses in this memoir the daily change of temperature with reference to the geographical position of the stations. By drawing a line through the places that enjoy the same temperature at the same instant of absolute time, he constructs what he denominates a *synthermal* line. A map containing such lines for 4^h A. M. and 2^h P. M. Greenwich mean time accompanies the memoir.

5. *Die Chemie der austrocknenden Oele, ihre Bereitung und ihre technische Anwendung in Künsten und Gewerben;* von G. J. MULDER. Nach der holländischen Original-Ausgabe bearbeitet von J. Müller, Berlin, 1867.—Mulder being asked what paint would best serve to protect iron from rusting, was unable to give an answer satisfactory to himself without first experimentally investigating the nature of paint and finding out wherein the drying of oils consists. He has brought to bear on this practical subject, his well known accuracy, tact, and thoroughness, and has obtained commensurate results. He has resolutely and perseveringly grappled the previously evasive Proteus of the drying oils, through its several shapes, and has at last elicited facts and principles which are all the more important for their bearing on matters of everyday life, —for their relation to the arts and to art. Most of his experiments were made on linseed oil, but he also devoted some attention to poppyseed oil and nut oil. The chief and distinctive constituent of all is "linolein" which consists of glycerin and "linoleic acid." The author tried in vain to obtain pure linoleic acid, for the more he worked with it the more it became contaminated with products of oxydation; and, as it is one of the very weak acids, he found it exceedingly difficult to produce salts which he could be sure were quite pure and normal. But there can be little doubt that its composition is $HO,C_{32}H_{27}O_3$. Linoleic acid being exposed in thin layers to the air, in a few days becomes oxydized

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to "linoxic acid,"—a sticky substance, like turpentine. By several months farther exposure, the linoxic acid dries and becomes "linoxyn," $C_{32}H_{27}O_{11}$,—an amorphous, tough, leathery matter insoluble in water, alcohol, ether, or dilute acids, but dissolving in alkalis to reproduce linoxates. Its best proper solvent is a mixture of alcohol and chloroform. Linoleate of lead readily oxydizes in the air to a white linoxate, which is not glutinous, but dry, hard, and brittle. And linseed oil boiled with a very little oxyd of lead so as to contain a small quantity of linoleate of lead, dries as well in a few days as isolated linoleic acid does in so many months. There are two linoxyns, the white and the red, and there are corresponding white and red linoxic acids. The white modifications become red by being heated to 80° C., and the red turn white again by continued exposure to sunlight. The browning of white paint in dark places, is owing to the gradual change of white linoxyn into red. Four linoxic acids are mentioned, having the same properties, but differing in respect to color and to the amount of HO in combination. White linoxic acid formed by the oxydation of linoleate of lead, is $HO,C_{32}H_{25}O_9$; that produced by the oxydation of free linoleic acid in the air, is $HO,C_{32}H_{25}O_9+2HO$. Red linoxic acid when separated from red linoxate of lead by chlorhydric acid and dried at 100° C., is $C_{32}H_{25}O_9$. The second of the above white linoxic acids on being heated for some time in a water bath, loses 6·7 per cent and leaves a blood red linoxic acid of the composition $HO,C_{32}H_{25}O_9$. It will be noticed that linoxyn, which is an indifferent substance, has a composition intermediate between this latter red linoxic acid and the white from which it is formed; but of course in linoxyn the molecular arrangement is different. Linoleic anhydrid,—$C_{32}H_{27}O_3$,—completes the list of peculiar substances which exist or may be formed in drying oils. More or less of it is always formed during the boiling of such oils, and it adds much to the goodness of boiled oil. It is an unalterable, elastic matter, like caoutchouc that has been melted.

Poppy seed oil and nut oil differ from linseed oil in containing laurin instead of palmitin, and their linolein gives only the white variety linoxyn. Hence not being liable to turn brown in the dark, they are better for artists' use. Linseed oil consists of about 80 p. c. of linolein, 10 p. c. of elaïn, and 10 p. c. of myristin and palmitin.

Mulder calls attention to what may be called the respiration of drying oils, for when they are spread out over a great surface they absorb oxygen and give out carbonic acid, like the blood of living animals. In drying, linseed oil increases in weight to the amount of from seven to twelve per cent over and above what it loses in the form of water and carbonic acid, together with small portions of acetic, formic, and acrylic acids. In the first place the glycerin of the linolein is all decomposed and carried off. Then the glycerin of the other constituents is gradually destroyed, so that at the end of three months not a trace of it is to be found. When this stage of the drying is completed, there remain linoxyn and palmitic, myristic, and elaic acids, and the paint is dry and flexible

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and elastic. But oxydation still goes on, though very slowly, and the fatty acids disappear. Finally the linoxyn itself undergoes decay and becomes unserviceable in binding colors or in protecting the painted surface.

The albuminous or mucilaginous matter which has so long figured in the books to account for slowness in the drying of unboiled oil, Mulder has searched for carefully but in vain; and he finds that fresh oil treated by any method which should simply remove albumen or mucilage, still dries no better than before. And, after all, this inappreciable substance, if it were present, would fail to explain what it was invented to account for: since there is no known reason why a matter that helps some oils oxydize to become rancid, should hinder others from oxydizing to become dry. It is therefore high time for science to consign this nonentity to the limbo of obsolete follies.

The oxyds and acetates of lead act as driers, not by precipitating albuminous matters, but by forming a little lineolate of lead, which oxydizes readily and communicates its activity to the oil itself. The addition of some manganese salts, such as the borate, accelerates the drying, because the loosely held oxyd of manganese oxydizes in the air and awakens the activity of the surrounding oil. No metallic oxyds or salts can act as driers unless they are brought into a state to combine chemically with the oil. Thus red oxyd of iron and zinc white and oxyd of tin are entirely inert. Sulphate of zinc or sulphate of manganese may act when oxyd of lead is added to combine with the sulphuric acid and set the other oxyd free; but without such addition, they are useless; and the oxyd of lead required for the decomposition would do more good if used alone. But oil treated with any driers by mere digestion, though it may dry quickly, can never be so good as oil boiled with suitable additions; because in boiling some linoleic anhydrid is formed, which being more adhesive and elastic than linoxyn, adds much to the value of oil for paint. The author, discarding numerous nonsensical receipts which are extant, recommends for preparing a colorless drying oil, which leaves nothing to be desired, to boil common linseed oil two hours with three per cent of red lead, filter it, and expose it to sunlight in large shallow vessels, the air over it being frequently renewed.

Mulder returning at length to the problem which gave rise to the investigation, rejects oil paints as unsuitable to prevent the rusting of iron, and concludes that coal tar contains the best materials for a protecting coat.

The book contains a great deal that is new, and the author has been, to use his own expression, "Getren dem Grundsatze, welcher uns Niederländean von Jugend auf beigebracht wird, nicht so ohne Weiteres dahin zu schreiben und sicher bei Behandlung von Gegenständen die Geschichte nicht zu vergessen." Of course he does not entirely exhaust his subject, but science is greatly enriched by this work, and it constitutes a masterly contribution to the chemistry of the arts. J. M. O.

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